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JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 5, PP. 411–443, PLS. 48–53, SEPTEMBER, 1938

CONODONTS OF THE OLENTANGY SHALE

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ABSTRACT

The Olentangy is a bluish shale containing lenses and thin layers of bluish limestone together with occasional thin beds of brown to black shale. It lies in the Devonian system between the Huron (basal Ohio) shale and the Delaware limestone throughout most of the state of Ohio but to the north other beds wedge in between it and the Huron shale. Except for microscopic forms the middle and lower parts of the Olentangy are sparingly fossiliferous. In some localities an abundance of new conodonts has been found where the lower beds crop out. These are herewith described and tabulated to show their distribution.

The Olentangy is a soft argillaceous blue shale with a few layers, lenses, and flat disc-like concretions of argillaceous blue limestone, and also with occasional thin layers of brown to black shale that resemble the overlying Huron or Ohio shale. Winchell named it from the outcrop along the Olentangy River at Delaware, Ohio (1).

The Olentangy shale forms the basal portion of the Hamilton in Ontario, where it crops out along the Ausable River and its tributaries, disappears beneath the drift, and crops out again south of Lake Erie. In Ohio it forms a number of poor outcrops just south of Sandusky, then is known only from well logs to Delaware County, Ohio. It again passes beneath the drift in southern Franklin County but reappears in Ross County, Ohio, and from thence crops out intermittently southward across the Ohio River into Kentucky (2). This shale increases in thickness from a minimum of a few inches at the south to a maximum of about 85 feet at the north. It rests on rocks of Marcellus age (Delaware limestone) in Ontario, northern and central Ohio, but southward overlaps this formation and rests on progressively older rocks until it is found in contact with the Niagaran. The upper beds of the Hamilton are gradually cut out by overlap of the Huron or basal portion of the Ohio black shales. In fact the Widder beds, or next succeeding member of the Hamilton above the Olentangy, has a representative south of Sandusky in the Prout limestone, the probable southern equivalent of the Encrinal limestone of the Arkona and Thedford regions in Ontario (3). In central and southern Ohio the Hamilton is composed of only the lower sparingly fossiliferous to almost barren beds of Olentangy shale. The sharp slightly undulating contact of the Olentangy-Ohio shales in central Ohio (4) suggests this overlap and the gradual southward disappearance of the intervening beds seems to establish it. The upper part of the Olentangy shale, particularly in the vicinity of Lake Erie and northward, is abundantly fossiliferous, but the lower part is generally characterized by few fossils of megascopic size. Spore cases occur in this shale in nearly every outcrop. These are probably *Sporangites huronensis* or a very closely related form, which is exceedingly abundant in some beds, especially the brown to black lenses that frequently appear in the blue to gray shales. But such spores are common throughout the whole Devonian of the Lake Erie region and especially in Ontario. As they need further study before they can be used for correlation, such spores, for the present at least, have no stratigraphic value. There are some megascopic fossils in this shale even in central Ohio. Although of Hamilton age they are generally too rare to help much in the correlation of the shales usually passing

under this name. The most important fossils are microscopic; among these the conodonts are abundant. The following table shows the distribution of the conodonts in the Olentangy shale:

DISTRIBUTION OF THE OLENTANGY CONODONTS
(The numbers refer to occurrence list)

	Southwestern Ontario	Ohio			
		Northwest	North Central	Central	South Central
Acodus formosus	152		147, 148		
Acodus inopinatus	153, 161, 178, 176		147, 148	114	
Acodus zionensis			147		
Ancyrodella buckeyensis				112, 118, 120	
Ancyrodella plena				112	125
Ancyrodella robusta				110	
Ancyrognathus asteroideus				110	
Ancyrognathus euglypheus				112	
Ancyrognathus sp.				187	
Bryantodus amalitus				187	
Bryantodus andersonensis				120	
Bryantodus argutus				187	
Bryantodus ausablensis	180				
Bryantodus bellatulus				187	
Bryantodus bennerensis			108		
Bryantodus? bezcensis				112	
Bryantodus bryanti	173			111, 117, 118, 121	
Bryantodus concavus Huddle				117	
Bryantodus dignatus				112	
Bryantodus eriensis	174			187	
Bryantodus grahami				109, 117, 187	
Bryantodus humboltensis			108	117	
Bryantodus ignotus	164		148		
Bryantodus imparilis				111, 120	
Bryantodus nobilis				112	
Bryantodus olentangiensis				187	
Bryantodus prosseri				111, 112, 118, 187	125
Bryantodus sciotoensis				120	
Bryantodus stratfordensis	156		108	111, 187	
Bryantodus sublimatus				111, 117	
Bryantodus wesleyianensis				187	125
Bryantodus winchelli				117	
Bryantodus sp.				109, 110, 117, 118, 187	
Cardiodus? leviculus	153				
Cervicornoides alternatus	156, 162		147, 148	104, 105, 108	111, 120, 187 125
Cervicornoides heterodentatus	153				
Ctenognathus deparcus				187, 109	139
Ctenognathus elegans	161, 172			111, 118, 120, 187	125
Ctenognathus falcatus				110, 111, 118, 187	
Ctenognathus falsiformis				120, 121	
Ctenognathus firmus				110, 187	
Cyrtoniodus? delicatus				112	
Cyrtoniodus worthingtonensis	156			117, 187	
Euprioniodina dora				187	
Euprioniodina sp. a				111	
Euprioniodina sp. b				112, 117	
Euprioniodina sp.	162, 168		105, 108	110, 111, 112, 117, 187	125
Falcodus incultus				111	
Falcodus sp.				109, 112, 187	
Gyrognathus carinatus				112	
Hibbardella? sp.				187, 120	
Hindeodella beta	160, 162			110, 112, 117	131
Hindeodella conferta				114, 117, 118, 120	125
Hindeodella fishingerensis	164		105	110, 117	
Hindeodella lambtonensis	173, 174, 175, 176, 180, 168, 169		105	110, 111, 117, 120, 187	125
Hindeodella milleri	159, 177, 168			110, 112, 117, 118, 120, 187	125
Hindeodella modesta	152, 172, 176		104, 105, 108	112, 118, 187	136
Hindeodella plumatella				109, 187	139
Hindeodella priscilla	178			110, 118, 120	
Hindeodella sp.	176			187	
Hindeodelloides abnormale				112	
Hindeodelloides cynthiana				187	
Hindeodelloides sp.				114, 187	
Icriodus arkonensis	152, 153, 154, 162		105, 107, 108		
Icriodus expansus	151, 152, 153, 156,	140B, 147,	105, 107, 108	114	
Branson and Mehl	158, 162, 173, 175, 180	148, 185			
Icriodus elegantulus	153, 156, 175, 180		108	110	

DISTRIBUTION OF THE OLENTANGY CONODONTS—*Continued*
(The numbers refer to occurrence list)

	Southwestern Ontario	Ohio			
		Northwest	North Central	Central	South Central
Icriodus cymbiformis ? Branson and Mehl	152, 154, 162	140B	104, 105, 107, 108	114	
Icriodus latericrescens Branson and Mehl	152, 153, 162		107, 108		
Ligonodina duplicata				120	
Ligonodina ? erratica				120	
Ligonodina eva				120	
Ligonodina franklinensis				120, 187	125
Ligonodina cf. *L. hindei* Ulrich and Bassler	151				
Ligonodina sp.	165, 167			111, 117, 120, 121, 187	125, 136
Ligonodinoides lewisensis				112, 187	
Ligonodinoides ohioensis				120	
Ligonodinoides welleri				112, 187	
Ligonodinoides sp.				111, 118, 187	
Lonchodina disjuncta	162			121	
Lonchodina inaequalis				111	
Lonchodina sp.	162		107	110, 111	125
Nothognathella angusta				111, 118	
Nothognathella bogartensis				111, 112	
Nothognathella delawarensis				111	
Nothognathella sp.		148		118, 121	125
Oistodus humilis		147			
Palmatolepis flabelliformis				109, 110, 111, 114, 117, 118, 187	125, 136
Palmatolepis marginatus				109, 110, 111, 117, 118, 187	125
Plectodina aculeata	168			112, 118	125
Plectodina armata			107	111, 118, 121	
Plectodina stouti				187	
Plectodina sp.	162, 167, 181			110, 111, 114, 118, 187	
Polygnathus basilicus				109	
Polygnathus comis				187	
Polygnathus decorosus	151, 152, 154, 155, 156, 158, 159, 162, 165, 166, 168, 172, 176, 177	148	107, 108	110, 111, 114, 117, 118, 187	125
Polygnathus sanduskiensis	151, 156, 161, 162, 165, 167, 169, 172, 173		105, 107, 108	111	
Polygnathus strongi	152, 162	148	105, 107, 108		125
Polygnathus webbi	178		107, 108	109, 111, 117, 187	
Prioniodella insolita				187	
Prioniodina aversa				111	
Prioniodina sp.			108	109	
Prioniodus affinis				111	
Prioniodus? alpheus				111	
Prioniodus? bifidus				111	
Prioniodus bownockeri	156			110	
Prioniodus idoneus				111	
Prioniodus longidentatus				110, 120	
Prioniodus powellensis				117	125, 136
Prioniodus smithi				187	
Prioniodus sp.				120, 122, 187	
Subprioniodus ? sp.				111, 121	125
Synprioniodina gracilis				109, 114, 118, 187	125
Synprioniodina sp.				117, 121	125
Tricognathus devonicus			104		
Tricognathus hoffmani	174				

The above table suggests the same fauna throughout the region under discussion. Out of 37 species of conodonts in the Olentangy shale of Ontario, 16 are common to these beds in north-central Ohio and 27 to central Ohio. And of the 21 species in the Olentangy shale of north-central Ohio, 17 species occur in the typical beds of central Ohio. Of the 26 species in south-central Ohio, all but one occur in central Ohio. The type section at Delaware as well as the similar sections on Deep Run and Slate Run in central Ohio yield an abundance of conodonts. Thus 101 species, together with fragments of others, were found in that region. This fauna of central Ohio is so much more abundant than those north and south of it that it is difficult to prove they are the same, although they are markedly simi-

lar and are believed by the writer to be the same (5). There seems greater probability, however, that the Olentangy shale of central Ohio is equivalent to the similar beds in northern Ohio, than that it is equivalent to those in southern Ohio.

A little more progress has been made in the classification of conodonts through the medium of X-rays. Dr. Duncan McConnell, of the Department of Geology, University of Minnesota, has prepared X-ray photographs of specimens of conodonts from the Decorah shale (Ordovician) of Fairbault, Minnesota, and from the Olentangy shale (Devonian) of Arkona, Ontario. The marked similarity of these diffraction patterns indicates that the composition of these specimens is essentially similar in that both are members of the apatite group of minerals. Accurate measurement of the X-ray films indicates that there are differences, to be sure, but these differences are not as great as those which were found for several apatite crystals which analysis showed to be somewhat different in composition. The composition of conodonts is also similar to that of vertebrate teeth, and both of these substances are to be classified as collophane.

Because the conodont specimens from vastly different horizons are essentially of the same composition, it is probable that the substance now present (collophane) represents the original substance of the teeth. The small, almost insignificant differences mentioned above are probably to be accounted for by slight changes in composition, which have taken place as diagenetic or later alterations. Carnot (6) has suggested that phosphates become progressively richer in fluorine by reaction with the fluorine compounds of water, particularly sea water. Reynolds, Jacob, and Hill (7) have recently obtained results in agreement with this theory, a theory which probably applies likewise to the composition of conodont specimens.

Regardless of the fact that conodont assemblages suggesting the tooth arrangement of Polychaeta have been found, chemical and physical analysis invariably point to the Vertebrata as their nearest kin. Whether this is trustworthy, of course, has not yet been proven, but preliminary studies of fish teeth from the Onondaga "bone-bed" of central Ohio, or even the teeth of fishes found in the Miocene of California, show that they are made up of a substance very similar to that of the conodonts. If one can be sure that this is the original substance (collophane) in both cases, and if one can also be sure that the original substance (chitin) occurs in the fossil Polychaeta, it becomes evident that the only way to relate conodonts to the worms is to postulate an entirely new group of extinct forms with vertebrate-like teeth, which might be equivalent to suggesting that they are primitive vertebrates. In fact the *Dinichthys* mouth had an assemblage of teeth almost as variable as that suggested by the conodont assemblages so far found.

OCCURRENCE

Conodonts have been found abundantly at some horizons and sparingly throughout the Olentangy shale, except in one or two localities. Even in these latter it is expected that a more diligent search will reveal them, and at least they may be expected wherever this formation occurs. The localities and horizons from which samples were taken are listed below. In the systematic part of this paper the numbers given for occurrence refer to this list.

DESCRIPTION OF LOCALITIES

101. The soft argillaceous blue shale 25 feet below the base of the Huron shale along Plum Creek, Prout Station, Erie County, Ohio.
102. The abundantly fossiliferous soft blue shale just below the pyritized zone, or about 36 feet below the base of the Huron shale, along Plum Creek, Prout Station, Erie County, Ohio.
103. The lowest part of the section along

Plum Creek, or about 40 feet below the base of the Huron shale, Prout Station, Erie County, Ohio.

104. The blue shale immediately below the Prout limestone, or about 9 feet below the base of the Huron shale, along the east branch of Pipe Creek, Bloomingville, Erie County, Ohio.
105. The blue shale about 25 feet below the base of the Huron shale along the east branch of Pipe Creek, Bloomingville, Erie County, Ohio.
106. The weathered blue shale about 30 feet below the base of the Huron shale along the east branch of Pipe Creek, Bloomingville, Erie County, Ohio.
107. The weathered shales at the base of the Prout limestone on the Allen Farr farm three-quarters of a mile northeast of Strong's Ridge, Huron County, Ohio.
108. The weathered blue shales about 5 feet below the base of the Prout limestone on the Allen Farr farm three-quarters of a mile northeast of Strong's Ridge, Huron County, Ohio.
109. The soft blue shale in the Olentangy River bluff at the southwest corner of the Marlborough Cemetery near the north line of Delaware County, Ohio.
110. The uppermost layer of the blue Olentangy shale, type section at Delaware, Ohio.
111. The upper three inches of Olentangy shale, type section at Delaware, Ohio.
112. The soft argillaceous blue beds of the Olentangy shale 4 feet below the base of the Ohio shale, type section at Delaware, Ohio.
113. The soft argillaceous blue beds of Olentangy shale 15½ feet below the base of the Ohio shale, type section at Delaware, Ohio.
114. The soft argillaceous blue beds of Olentangy shale 21 feet below the base of the Ohio shale, type section at Delaware, Ohio.
115. The soft argillaceous blue beds of Olentangy shale 26 feet below the base of the Ohio shale, type section at Delaware, Ohio.
116. The soft argillaceous pale-blue to greenish beds of Olentangy shale immediately below the Ohio shale along Slate Run, near Dublin, Franklin County, Ohio.
117. The soft argillaceous bluish-green Olentangy shale 7½ feet below the base of the Ohio shale along Slate Run, near Dublin, Ohio.
118. The soft bluish-green Olentangy shale 17 feet below the base of the Ohio shale along Slate Run, near Dublin, Ohio.
119. The fossiliferous nodular limestone 16½ feet below the base of the Ohio shale along Slate Run, near Dublin, Ohio.
120. The bluish-green argillaceous Olentangy shale 18½ feet below the base of the Ohio shale along Slate Run, near Dublin, Ohio.
121. The soft bluish-green Olentangy shale immediately overlying the Delaware limestone along Bartholomew Run, Delaware County, Ohio.
122. The soft bluish-green Olentangy shale 10 feet above the Delaware limestone along Bartholomew Run, Delaware County, Ohio.
123. The soft blue beds of Olentangy shale 16 feet above the Delaware limestone along Bartholomew Run, Delaware County, Ohio.
124. The soft blue beds of Olentangy shale 20 feet above the Delaware limestone along Bartholomew Run, Delaware County, Ohio.
125. The bluish argillaceous beds of Olentangy shale 23 feet below the base of the Ohio shale, Benner Hill section, Bainbridge, Ross County, Ohio.
126. The weathered soft blue beds of Olentangy shale 13 feet below the base of the Ohio shale, Benner Hill section, Bainbridge, Ross County, Ohio.
127. The soft bluish-gray beds of Olentangy shale 4 feet below the base of the Ohio shale, Black Hollow School, Adams County, Ohio.
128. The soft blue beds of Olentangy shale 25 feet below the base of the Ohio shale, Black Hollow School, Adams County, Ohio.
129. The soft blue beds of Olentangy shale 31 feet below the base of the Ohio shale, Black Hollow School, Adams County, Ohio.
130. The soft blue beds of Olentangy shale 37 feet below the base of the Ohio shale, Black Hollow School, Adams County, Ohio.
131. The gray beds of Olentangy shale immediately below the base of the Ohio shale seven-eighths mile west of Mount Zion School, Adams County, Ohio.
132. The blue beds of Olentangy shale 6 feet below the base of the Ohio shale, seven-eighths mile west of Mount Zion School, Adams County, Ohio.
133. The bluish-green beds of Olentangy shale 9 feet below the base of the Ohio shale, seven-eighths mile west of Mount Zion School, Adams County, Ohio.
134. The blue beds of Olentangy shale 11 feet below the base of the Ohio shale seven-eighths mile west of Mount Zion School, Adams County, Ohio.
135. The bluish-green beds of Olentangy shale 14 feet below the base of the Ohio shale, seven-eighths mile west of Mount Zion School, Adams County, Ohio.
136. The gray to bluish beds of Olentangy

shale immediately below the base of the Ohio shale at Sulphur Lick School, Adams County, Ohio.

137. The gray beds of Olentangy shale 6 feet below the base of the Ohio shale, at Sulphur Lick School, Adams County, Ohio.
138. The soft blue to gray beds of Olentangy shale 11 feet below the base of the Ohio shale at Sulphur Lick School, Adams County, Ohio.
139. The gray beds of Olentangy shale 17 feet below the base of the Ohio shale at Sulphur Lick School, Adams County, Ohio.
140A. The top of the 8 foot bed forming the west wall of the quarry in the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
140B. The bottom of the 8 foot bed forming the west wall of the quarry in the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
141. The argillaceous blue limestone lying 4 feet below the bottom of the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
142. The argillaceous blue limestone 2 feet below the base of the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
143. The argillaceous blue beds forming the base of the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
144. The soft blue beds 2 feet above the base of the Silica (Hamilton) shale at Silica, Lucas County Ohio.
145. The soft blue beds 4 feet above the base of the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
146. The soft blue beds 6 feet above the base of the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
147. The soft blue beds 8 feet above the base of the Silica (Hamilton) shale at Silica, Lucas County, Ohio.
148. The soft blue beds 10 feet above the base of the Silica (Hamilton) shale or at the top of this shale, at Silica, Lucas County, Ohio.
149. The weathered blue beds of Olentangy shale 6 feet above the Silurian limestone on the A. C. Pinkston farm, four miles west of Vanceburg, Kentucky.
150. The weathered blue beds of Olentangy shale 9 feet above the Silurian limestone on the A. C. Pinkston farm, four miles west of Vanceburg, Kentucky.
151. The soft blue beds of the Olentangy shale immediately below the Encrinal limestone (basal Widder beds) at the brick plant in Thedford, Lambton County, Ontario.
152. The soft blue beds of the Olentangy shale about 20 feet below the base of the Encrinal limestone (basal Widder beds) at the brick plant in Thedford, Lambton County, Ontario.
153. The soft blue beds of the *Microcyclas* zone in the Olentangy shale one and one half miles north of Thedford, Lambton County, Ontario.
154. The Olentangy shale 10 feet below the *Microcyclas* zone one and one half miles north of Thedford, Lambton County, Ontario.
155. The soft blue beds of the Olentangy shale 25 feet below the top of the formation at Crinoid Hill, Lambton County, Ontario.
156. The soft blue beds of the Olentangy shale, 30 to 40 feet below the Encrinal limestone along the Ausable River at Crinoid Hill, Lambton County, Ontario.
157. The Olentangy shale 40 feet below the Encrinal limestone on the Ausable River in Lambton County, Ontario, opposite Frazer's place.
158. The lowest outcrop of Olentangy shale, about 50 feet below the Encrinal limestone on Robert Frazer's place in Middlesex County, Ontario. This outcrop is at or near water level in the Ausable River.
159. The soft blue shale partings in the limestones forming the upper part of the Widder beds at No. 4 Hill, Lambton County, Ontario.
160. The top beds of the Olentangy shale at No. 4 Hill, Lambton County, Ontario.
161. The Olentangy shale about 40 feet below the Encrinal limestone at the junction of Rock Glen and Ausable River, Lambton County, Ontario.
162. The Olentangy shale about 40 feet below the Encrinal limestone at the Ausable River on Lot 8, Middlesex County, Ontario.
163. The blue clay shale in the upper part of the Ipperwash limestone one mile northeast of Ravenswood, Lambton County, Ontario.
164. The blue shales of the Widder beds 35 feet above the coral zone, Rock Glen section, Arkona, Lambton County, Ontario.
165. The soft blue shales of the Widder beds 26 feet above the coral zone, Rock Glen section, Arkona, Lambton County, Ontario.
166. The soft blue shales of the Widder beds 24 feet above the coral zone, Rock Glen section, Arkona, Lambton County, Ontario.
167. The blue shales of the Widder beds 15 feet above the coral zone, Rock Glen section, Arkona, Lambton County, Ontario.
168. The blue shales of the Widder beds 7 feet above the coral zone, Rock Glen

section, Arkona, Lambton County, Ontario.

169. The bluish shale of the Widder beds 5 feet above the coral zone, Rock Glen section, Arkona, Lambton County, Ontario.
170. The shaly material of the coral zone, Widder beds, Rock Glen section, Arkona, Lambton County, Ontario.
171. The soft blue beds immediately below the Encrinal limestone and forming the top of the Olentangy shale, Rock Glen section, Arkona, Lambton County, Ontario.
172. The soft blue beds 10 feet below the top of the Olentangy shale, Rock Glen section, Arkona, Lambton County, Ontario.
173. The soft blue beds 19 feet below the top of the Olentangy shale, Rock Glen section, Arkona, Lambton County, Ontario.
174. The soft blue beds 25 feet below the top of the Olentangy shale, Rock Glen section, Arkona, Lambton County, Ontario.
175. The *Microcyclas* zone of the Olentangy shale, at the dam on Ausable River, Middlesex County, Ontario.
176. The shaly material of the coral zone, Widder beds, Ausable River bluff in Middlesex County opposite Marsh's Mill, Ontario.
177. The soft blue beds forming the top of the Olentangy shale, Ausable River bluff in Middlesex County opposite Marsh's Mill, Ontario.
178. The soft blue beds 19 feet below the top of the Olentangy shale, Ausable River bluff, in Middlesex County opposite Marsh's Mill, Ontario.
179. The soft blue beds of the Olentangy shale 20 feet below the base of the Encrinal limestone, Ausable River bluff in Middlesex County opposite Marsh's Mill, Ontario.
180. The soft blue beds of the Olentangy shale at water level 26 feet below the Encrinal limestone, Ausable River bluff in Middlesex County opposite Marsh's Mill, Ontario.
181. The soft bluish shale of the Widder beds 12½ feet above the Encrinal limestone, Ausable River bluff in Middlesex County opposite Marsh's Mill, Ontario.
182. The gray layers in the Ohio black shale at Glenmary Park, Franklin County, Ohio. Sample collected by Dr. Wm. A. P. Graham.
183. The basal layers of the Silica shale at Silica, Lucas County, Ohio.
184. The middle layers, or about 5 feet above the bottom, of the Silica shale, Silica, Lucas County, Ohio.
185. The upper beds of the Silica shale at Silica, Lucas County, Ohio.
186. The top of the Olentangy shale at Deep Run, Franklin County, Ohio. Sample collected by Dr. Wm. A. P. Graham.
187. The middle of the Olentangy shale at Deep Run, Franklin County, Ohio. Sample collected by Dr. Wm. A. P. Graham.
188. The soft blue beds of the Olentangy shale about 20 feet below the base of the Encrinal limestone, Rock Glen section, Arkona, Lambton County, Ontario.

SYSTEMATIC DESCRIPTIONS

ACODUS FORMOSUS Stauffer, n. sp.
Plate 49, figure 33

Dental unit consists of slender tapering cusp, slightly bowed inward, laterally flattened, inner edge rounded and tapering but slightly, outer sharp and curving to the tip mostly above middle of cusp. Base expanded, enclosing deep pit with elliptical edge.

Holotype.—B 4905; Geological Museum, University of Minnesota.

Occurrence.—147.

ACODUS INOPINATUS
Stauffer, n. sp.
Plate 49, figures 23, 34, 35

Dental unit consisting only of cusp, slender, tapering, subtriangular in cross-section with flattened or basal side in and rounded apex of triangle outward. Lateral edges sharp, flaring out at base to inclose a deep sub-conical cavity.

Syntypes.—B 4906, B 4904, B 4903; Geological Museum, University of Minnesota.

Occurrence.—147, 176.

ACODUS ZIONENSIS
Stauffer, n. sp.
Plate 49, figure 30

Dental unit consists of small, short, stout, rapidly tapering cusp, sub-triangular in cross-section with base of section much shorter than height; sharp edge

curves rapidly to tip in upper half of cusp. Base flares out slightly, enclosing deep pit triangular in cross-section.

Holotype.—B 4907; Geological Museum, University of Minnesota.

Occurrence.—147.

ANCYRODELLA BUCKEYENSIS
Stauffer, n. sp.
Plate 52, figures 17, 18, 23, 24

Thick dental plate with two anterior lobes of arrow-shaped portion semi-symmetrical and posterior lobe nearly straight. Under side smooth except for grooved keel on posterior lobe and rather deep pit where this groove meets carinae or keels from the three corners of arrow-shaped plate. Oral surface with slightly arched median dental ridge from tip of arrow to lower end of posterior lobe. Two other denticulate ridges bisect the halves of plate, meeting the median approximately above basal pit. Scattered marginal denticles or ridges suggest radiation from median dental ridge.

Syntypes.—B 4942, B 4945; Geological Museum, University of Minnesota.

Occurrence.—112, 120.

ANCYRODELLA PLENA
Stauffer, n. sp.
Plate 52, figures 21, 22

Dental plate with arrow-shaped part hollowed out or concave and deeply notched at posterior. Posterior lobe straight or but slightly bowed. Underside with four keels converging to corners of square pit near posterior margin and showing faintly marked radiating ridges corresponding to furrows between ridges on upper side. Oral surface with median denticulated ridge, originating in rather sharp discrete denticles at anterior point of plate, which soon become crowded and coalesce into the ridge, which extends back along posterior lobe. Ridges and furrows radiating from median ridge more or less distinct over surface and terminating in marginal denticles.

Holotype.—B 4944; Geological Museum, University of Minnesota.

Occurrence.—112.

ANCYRODELLA ROBUSTA
Stauffer, n. sp.
Plate 52, figures 28, 29

Dental plate thick, distinctly asymmetrical. Under surface nearly smooth except for furrowed keels meeting in small subcentral pit on plate. Oral surface with nearly smooth ridge from tip of plate to base of posterior lobe. Ridges extending outward from subcentral part of plate to its posterior corners are rough, slightly crenulated, but not distinctly denticulate. Other nodose ridges radiate from median ridge, especially on lobate side. The condition suggests senile character of individual possessing this dental plate.

Holotype.—B 4948; Geological Museum, University of Minnesota.

Occurrence.—110.

ANCYROGNATHUS ASTEROIDEUS
Stauffer, n. sp.
Plate 52, figures 8, 9

Base a five-pointed more or less star-shaped plate with nearly equally developed points. Under side of plate bears a small median pit at which the slightly grooved keel bifurcates and two secondary keels are introduced to extend forward into the anterior lateral lobes. Most of under surface nearly smooth but showing faintly impressed concentric lines at several places. Upper or oral surface nodose and with nodose ridges extending into the lobes. These do not cross in the center of the plate but bend or arch to form pairs with the odd point isolated.

Holotype.—B 4753; Geological Museum, University of Minnesota.

Occurrence.—110.

ANCYROGNATHUS EUGLYPHEUS
Stauffer, n. sp.
Plate 53, figure 18

Plate thick, heavy, somewhat arrow-shaped including plate and blade, arched from base to tip of blade-like portion, high keel below dividing at small central pit and one branch extending to each point of plate. Oral surface with massive

blade, which is distinctly the tip of arrow-shaped plate and bears four or five large flattened denticles increasing in height rapidly from tip of blade then abruptly descending to the small uniform denticles of median ridge of plate. This median ridge bifurcates sending one to each of basal forks and on that preserved extending to point. General surface papillose or nodose with denticles along margin adjacent to blade.

Holotype.—B 4972; Geological Museum, University of Minnesota.

Occurrence.—112.

BRYANTODUS AMALITUS
Stauffer, n. sp.
Plate 48, figures 18, 19

Base broad, thick, a very slight suggestion of flattening or escutcheon beneath the cusp, aboral surface mostly keeled, sides rounded. Anterior limb is the broader, bearing eight, ten, twelve or more nearly straight denticles tending to parallel the cusp, and with denticle next to cusp large, making almost a double cusp. Posterior limb bears eight or ten, possibly more, small straight sharp denticles paralleling cusp. Denticles and cusp slightly compressed laterally, edges confluent throughout most of their length.

Syntypes.—B 4758, B 4759; Geological Museum, University of Minnesota.

Occurrence.—187.

BRYANTODUS ANDERSONENSIS
Stauffer, n. sp.
Plate 49, figure 17

Base highly arched, keeled, with small pit beneath cusp, both outer and inner sides carinate. Outer carina especially prominent at base of cusp, where it forms a process extending downward into a small spur. Anterior limb with eight or nine closely appressed denticles of diminishing length from cusp; posterior probably with similar series although but two are preserved here. Cusp of medium size, convex on both sides, sharpest edge on posterior. Cusp and denticles directed posteriorly.

Holotype.—B 4791; Geological Museum, University of Minnesota.

Occurrence.—120.

BRYANTODUS ARGUTUS
Stauffer, n. sp.
Plate 48, figures 16, 20

Base of varying width, biconvex in cross-section, a shallow elongate excavation on under side supplanted by a keel towards extremities. Anterior limb broad with eight or ten small thick denticles parallel or tending to curve into parallelism with cusp. Posterior limb narrow, thin, twisted, with a similar number of denticles decreasing in length posteriorly and all parallel to cusp. Cusp small, only slightly larger than denticles.

Holotype.—B 4756; paratype, B 5097, Geological Museum, University of Minnesota.

Occurrence.—187.

BRYANTODUS AUSABLENSIS
Stauffer, n. sp.
Plate 51, figure 19

Base thin, highly arched, bowed inward, with groove and shallow excavation beneath cusp. Anterior limb bears seven or more denticles of various sizes, all directed backward, the four nearest cusps more or less bunched or combined into a compound denticle. Posterior limb fragmentary but apparently not so large, with a series of small denticles, remnants of which are preserved. Cusp long, straight, flattened on inner but slightly convex on outer side. Cusp and denticles laterally compressed.

Holotype.—B 5068; Geological Museum, University of Minnesota.

Occurrence.—180.

BRYANTODUS BELLATULUS
Stauffer, n. sp.
Plate 48, figure 23

Base deep, thick, highly arched, with a stout keel and a small pit (escutcheon) just posterior to base of cusp; outer side rounded but becoming carinate towards the front and bearing a row of tubercles

grouped by twos; inner side carinate, flangelike at cusp and posterior thereto, also tuberculate. Eight or more denticles on anterior limb, probably as many or more on the posterior. Nearly all denticles, particularly those near cusp, have two germ units; all curve slightly inward. Cusp massive but sharply pointed and having four or more germ units in its base. Conodonts of this type, belonging to the genus *Bryantodus*, show a marked relationship to *Nothognathella* Branson and Mehl.

Holotype.—B 4760; Geological Museum, University of Minnesota.

Occurrence.—187.

BRYANTODUS BENNERENSIS
Stauffer, n. sp.
Plate 51, figure 4

Base very slightly arched, bowed or bent inward at front edge of cusp,shallow groove on under side becoming narrow conical pit, bottom of which curves with cusp. Anterior limb probably short, curving inward and downward, with three or four, possibly more, backward-curving denticles; posterior straight with irregular series of backwardly directed, closely crowded denticles. Cusp strong, curving parallel to denticles, edges parallel to limbs of bar.

Holotype.—B 4838; Geological Museum, University of Minnesota.

Occurrence.—108.

BRYANTODUS? BEZOENSIS
Stauffer, n. sp.
Plate 51, figure 14

Bar thick, slightly arched, flattened under side becoming depressed into broad shallow pit beneath cusp. Denticles crowding at bases only, four on posterior limb and probably similar set on anterior, which is fragmentary. Cusp strongly developed, slightly flattened on outer face, bending into parallelism with posterior denticles, with cutting edges tending to extend in line of limbs.

Holotype.—B 5064; Geological Museum, University of Minnesota.

Occurrence.—112.

BRYANTODUS BRYANTI
Stauffer, n. sp.
Plate 49, figure 18

Base arched, keeled at ends but with well-developed pit beneath cusp, from which furrows extend outwards. Anterior limb relatively short, carrying a diminishing series of four or five large, closely appressed denticles; posterior with eight to ten closely appressed sharp-pointed denticles together with several extra germ denticles. Cusp large, flattened, sharp-pointed, inclined posteriorly parallel to denticles.

Holotype.—B 5061; Geological Museum, University of Minnesota.

Occurrence.—121.

BRYANTODUS CONCAVUS Huddle
Plate 48, figure 14

Bryantodus concavus HUDDLE, *1934*, Bull. Am. Paleontology, vol. 21, p. 71, pl. 2, figs. 15–17.

Base broad, laterally compressed, strongly arched, keeled, with excavation (escutcheon) very small or wanting. Eight or more anterior denticles curve slightly and tend to parallel cusp. The few posterior denticles preserved are straight and parallel to cusp. All denticles confluent. Cusp sharply pointed, similar to and only slightly larger than denticles.

Figured specimen.—B 4754; Geological Museum, University of Minnesota.

Occurrence.—117.

BRYANTODUS DIGNATUS
Stauffer, n. sp.
Plate 48, figure 29

Base highly arched, slightly twisted or bowed, rounded on outer and strongly carinate or flanged on inner side, with well developed keel slightly flattened beneath cusp. Anterior limb with twelve or more sharp denticles; posterior with ten or more, similar but shorter and less regular. Cusp sharp but not very strongly developed. Cusp and denticles roundly elliptical in cross section, but with edges confluent throughout most of their length.

Holotype.—B 4769; Geological Museum, University of Minnesota.
Occurrence.—112.

BRYANTODUS ERIENSIS
Stauffer, n. sp.
Plate 48, figure 11

Base thick, laterally curved or bowed, slightly arched, with a rough broad keel apparently running full length. Sides of base thickened, rounded and with a tubercle inside near base of cusp. Eight or ten irregular denticles on anterior limb free only near tips, ten or more similar ones on posterior limb. Denticles all stout, rounded in cross-section, probably increasing in number by both terminal additions and implantation. Cusp small, pointed, nearly straight.

Holotype.—B 4751; Geological Museum, University of Minnesota.
Occurrence.—187.

BRYANTODUS GRAHAMI
Stauffer, n. sp.
Plate 48, figures 22, 24;
plate 49, figure 8

Base thick, deep anteriorly, shallower towards posterior, arched, posterior end bowed or twisted, under side flattened beneath the cusp but keel well developed near ends. Oral side with a very prominent carina that becomes a flange, aboral side with similar, but less prominent and more rounded carina. Outer margins of flange-like portions of carinae covered with tubercles, especially near and posterior to cusp, Anterior denticles irregular but generally longer than posterior and all confluent near the base. About ten or twelve denticles on each limb. Cusp moderately developed and about centrally placed.

This species is one of the fine specimens from a collection made by Dr. Wm. A. P. Graham at Deep Run near Worthington, Ohio, and therefore named after him.

Holotype.—B 4764; paratypes, B 4762, B 4782; Geological Museum, University of Minnesota.
Occurrence.—187.

BRYANTODUS HUMBOLTENSIS
Stauffer, n. sp.
Plate 49, figure 15

Base thick, relatively deep, nearly circular in cross-section, strongly arched, the two limbs forming an angle of about 125°, a shallow pit beneath cusp, both limbs slightly furrowed or grooved, but sides of groove uniting to form a keel near anterior end and probably the same near posterior. Anterior limb with a small denticle tight against cusp, then four, possibly five, short stout denticles to end. Posterior limb with series of eight or ten, possibly more, similar spike-like denticles of which five are preserved. Cusp slender, rounded in cross-section, placed at crest of arch and inclined like denticles at an angle of about 145° to anterior limb.

Holotype.—B 4789; Geological Museum, University of Minnesota.
Occurrence.—108.

BRYANTODUS IGNOTUS
Stauffer, n. sp.
Plate 49, figure 3

Base arched, limbs forming an angle of about 140°, beneath cusp a small pit with slight groove extending forward but posterior limb keeled almost throughout. Anterior limb bears a series of small denticles, confluent at base, parallel to cusp and nearly at right angles to base. Only three of these partially preserved. Posterior limb with twelve or more closely set forward-curving denticles, confluent except at tips. Cusp large, laterally compressed and confluent with adjacent denticles.

Holotype.—B 4777; Geological Museum, University of Minnesota.
Occurrence.—164.

BRYANTODUS IMPARILIS
Stauffer, n. sp.
Plate 48, figure 3

Base sharply arched, the two limbs making an angle of about 135°. A small pit beneath cusp with the limbs narrowly grooved in its immediate vicinity, sides

of groove uniting to form a keel at least on the anterior limb. Anterior limb with six backward-curving denticles of irregular size; posterior somewhat fragmentary but probably with similar number since the white denticles may be seen penetrating the amber-colored base. Cusp central, directed posteriorly, nearly planoconvex in cross-section with greater curvature on outer side.

Holotype.—B 4786; Geological Museum, University of Minnesota.

Occurrence.—120.

BRYANTODUS NOBILIS
Stauffer, n. sp.
Plate 49, figure 14

Base highly arched, very slightly flexed, keeled, with very slight development of pit beneath cusp, lateral surfaces rounded, the outer almost carinate. Anterior limb with ten to twelve closely appressed denticles diminishing in length anteriorly; posterior fragmentary but probably about same length as anterior and with a similar series of denticles, of which two are preserved. Cusp with several germ denticles incorporated in base; short, stout, pointed, inclined parallel to denticles; cross section like denticles, lenticular but with vertical ridge which extends below base, carrying with it the similar but somewhat sharper outer ridges of the limbs to form a short prominent spur.

Holotype.—B 4788; Geological Museum, University of Minnesota.

Occurrence.—112.

BRYANTODUS OLENTANGIENSIS
Stauffer, n. sp.
Plate 48, figures 27, 28

Base thick, broadly arched, deeper on anterior limb, keel low or nearly disappearing beneath the cusp, outer side rounded, inner carinate and, at the top of the arch adjacent to the cusp, becoming flanged and slightly nodose along margin. Anterior limb with twelve or more denticles; posterior with eight or ten, possibly more, much shorter and slightly irregular. Cusp sharply pointed with two extra germ denticles partly erupted but remaining an integral part of the cusp.

Syntypes.—B 4767, B 4768; Geological Museum, University of Minnesota.

Occurrence.—187.

BRYANTODUS PROSSERI
Stauffer, n. sp.
Plate 49, figures 1, 4

Base moderately arched, bowed on posterior limb, thick, with slightly furrowed keel, which develops a small escutcheon beneath cusp. Outer side of base roundly carinate, with occasional tubercles along crest of carina. Inner side strongly carinate, with occasional nodes, four or five of which, adjacent to cusp, form a slight shelf. Anterior limb long, with about fifteen or sixteen closely appressed slender irregular denticles united nearly throughout their lengths. Posterior limb with about ten short sharp irregular denticles curving slightly inward and somewhat out of line with cusp and anterior denticles. Cusp rather small.

Holotype.—B 4775; paratype, B 4778; Geological Museum, University of Minnesota.

Occurrence.—111, 112.

BRYANTODUS SCIOTOENSIS
Stauffer, n. sp.
Plate 48, figure 21

Base thin, arched, slightly bowed, with shallow excavation just posterior to cusp. Anterior limb with four or more denticles that curve upward and tend to point in same direction as cusp. Posterior limb with eight or more denticles about parallel to cusp. Cusp stout, tapering moderately, compressed more on outer than inner side. Cusp and denticles confluent near base. Some of the denticles appear to originate from two germ or embryonic units. But this has been noted in other species and it is probable that one of such a pair of units might have erupted later had the individual continued to live.

Holotype.—B 4761; Geological Museum, University of Minnesota.

Occurrence.—120.

BRYANTODUS STRATFORDENSIS
Stauffer, n. sp.
Plate 48, figure 17;
plate 49, figure 6

Base slightly bowed or laterally curved, rather highly arched, of moderate breadth, thick, with a prominent ridge or carina running all along each side. Apparently aboral keel of anterior limb becomes the inner margin, and keel of posterior limb becomes the outer margin of the very slightly marked escutcheon. Anterior limb bears ten or more sharp denticles curving into approximate parallelism with the cusp, the one nearest the cusp being largest. Posterior limb bears twelve to fourteen or more denticles of diminishing size, all about parallel to cusp. Denticles seem to increase in number by implantation next to cusp and by addition at ends. Cusp somewhat enlarged, making an angle of 60° with base at point of insertion. Cusp and denticles deeply set, slightly compressed laterally, confluent throughout most of their lengths.

Holotype.—B 4757; paratype, B 4780; Geological Museum, University of Minnesota.

Occurrence.—111, 187.

BRYANTODUS SUBLIMATUS
Stauffer, n. sp.
Plate 49, figure 7

Base slightly arched, strongly bowed, keeled with very small escutcheon, carinae poorly developed. Anterior limb with seven or more irregular stout slightly flattened denticles; posterior with six or more similar ones. All denticles originate deep in base, are nearly straight, and tend to parallel cusp at an angle of about 60° with base. Cusp well developed, tapering to point, laterally compressed but edges not very sharp.

Holotype.—B 4781; Geological Museum, University of Minnesota.

Occurrence.—111.

BRYANTODUS WESLEYIANENSIS
Stauffer, n. sp.
Plate 48, figure 32

Base highly arched, anterior limb nearly twice as deep as posterior but both about same length. Aboral keel well developed, only slightly flattened beneath cusp. Slight carina on outer side, prominent carina on inner. Anterior limb with about fourteen denticles, irregular in size; posterior with eight or ten, possibly more, irregular and slightly smaller, all somewhat divergent from direction of cusp. Cusp well developed, slender, but not greatly exceeding denticle immediately anterior to it.

Holotype.—B 4772; Geological Museum, University of Minnesota.

Occurrence.—187.

BRYANTODUS WINCHELLI
Stauffer, n. sp.
Plate 48, figure 33

Base highly arched, rather thick, deep in anterior but shallow in posterior limb. Aboral surface with a broad shallow groove deepest beneath cusp and disappearing toward each extremity where its inner margin becomes the keel. Outer carina irregular, with rounded edge set here and there with tubercles. Inner carina strongly developed in center portion but disappears toward extremities; bears a regular row of about equally spaced tubercles along the edge. Anterior limb with about fourteen strong deeply set coalesced denticles; posterior with eight, ten, or more small sturdy ones. Cusp stout, more or less coalesced with adjacent anterior denticles.

Holotype.—B 4773; Geological Museum, University of Minnesota.

Occurrence.—117.

CARDIODUS? LEVICULUS
Stauffer, n. sp.
Plate 51, figure 22

Base semicircular or highly arched, convex on outer, slightly concave on inner side, deeply excavated throughout. Edge formed by union of convex and con-

cave sides becomes denticle-bearing ridge extending slightly below central part at each end. Cusp directed backward, only slightly larger than denticle which precedes, and is directed forward. A much smaller denticle, directed backward, follows cusp.

Holotype.—B 5092; Geological Museum, University of Minnesota.

Occurrence.—153.

Genus CERVICORNOIDES
Stauffer, n. gen.

Dental units consisting of a long slightly arched bar, which may be bowed or curled. Its under edge slightly furrowed or grooved, but may appear to be keeled. Anterior limb nearly straight, with a series of straight or slightly curving denticles usually alternating with groups of smaller ones. Posterior limb slightly curved, with double series of denticles, which may be nearly vertical but usually incline to posterior. Cusp rounded or flattened in front, curving inward, inclined with posterior denticles, base extending down across bar to form part of enclosure to deep pit beneath.

Genotype.—Cervicornoides alternatus.

CERVICORNOIDES ALTERNATUS
Stauffer, n. sp.
Plate 48, figures 10, 13

Bar slightly arched, fairly deep but rather thin. Anterior limb straight but set at downward angle of about 30° with continuation of posterior limb; bears four large denticles with groups of two or three smaller ones between. Posterior limb slightly arched, end curled or bowed inward, with three or four large denticles alternating with groups of two to five small needlelike ones, all directed backward, becoming more nearly horizontal near posterior end. Cusp slender, flattened on outer side, rounded on inner, inclining towards posterior, curving inward, lower portion extending along concave inner side of base to form inner part of deep pit beneath.

Syntypes.—B 4922, B 4925; Geological Museum, University of Minnesota.

Occurrence.—104, 120.

CERVICORNOIDES HETERODENTATUS
Stauffer, n. sp.
Plate 51, figure 11

Bar with rounded cross section, bowed, broadly grooved below, with thin well-defined keel in groove of posterior limb, deep pit with widely flaring margin beneath cusp. Posterior limb somewhat curled inward at or near extremity, set with series of variable denticles, which incline backward and tend to alternate large and small. Anterior limb stouter, straighter, with series of larger straighter denticles. Cusp slightly flattened on outer side but rounded on inner, inclined slightly to rear, curving abruptly inward, its base extending down shoulder-like along inner side of bar to join the greatest flare of basal cavity.

Holotype.—B 4845; Geological Museum, University of Minnesota.

Occurrence.—153.

CTENOGNATHUS DEPARCUS
Stauffer, n. sp.
Plate 48, figures 26, 31

Bar or base thin, deep, slightly arched, with well-developed pit beneath cusp and very narrow furrow extending therefrom but disappearing before reaching ends of base. Upper edge of each limb set with three to four sharp-edged discrete denticles, which arise deep within the base. Cusp at top of arch, slightly larger than denticles and having one or two germ denticles incorporated within its basal portion.

Syntypes.—B 4750, B 4766; Geological Museum, University of Minnesota.

Occurrence.—109.

CTENOGNATHUS ELEGANS
Stauffer, n. sp.
Plate 48, figures 9, 12

Bar or base thin, deep, very slightly arched and bowed inward, keeled, with small pit beneath cusp. Anterior limb with ten to twelve crowded denticles increasing in size towards the cusp; posterior with similar number decreasing in size from cusp to end. Denticles tend to

parallel cusp, all deeply inserted and with edges confluent except at tips. Cusp compressed, slender, elongate, making an angle of about 60° with base.

Syntypes.—B 4749, B 4752; Geological Museum, University of Minnesota.

Occurrence.—120, 118.

Ctenognathus falcatus
Stauffer, n. sp.
Plate 48, figures 1, 5

Base thin and laterally curved or bowed, having, beneath the cusp, a slight excavation (escutcheon) with a very narrow groove extending anteriorly and posteriorly therefrom. Anterior limb with ten, fifteen or more slender denticles originating deep within it, usually starting at right angles to it but soon curving back to approximate direction of the cusp. Posterior limb with ten, perhaps twelve or more, slender relatively straight sharp denticles originating deep within the base and with an occasional small denticular wedge or germ denticle not yet erupted from base. All denticles crowded, laterally compressed and fused except near the apices. Cusp of moderate size, usually slender, sharp pointed and curving markedly backward.

Syntypes.—B 5062, B 4745; Geological Museum, University of Minnesota.

Occurrence.—111, 187.

Ctenognathus falsiformis
Stauffer, n. sp.
Plate 48, figures 4, 7

Base thin, slightly arched to nearly straight, bowed inward, small pit or excavation beneath cusp, with very short furrows leading anteriorly and posteriorly, but most of under side sharply keeled. Anterior limb with eleven or twelve nearly straight sharp denticles; posterior with nine or ten, possibly more, similar but growing shorter and more nearly recumbent towards extremity. Cusp slender, long, inclined like adjacent denticles at an angle of about 60°. Both cusp and denticles confluent except at tips.

Holotype.—B4744; paratype, B4747; Geological Museum, University of Minnesota.

Occurrence.—120, 121.

Ctenognathus firmus
Stauffer, n. sp.
Plate 48, figures 2, 6, 15

Base thin, laterally curved or bowed, under side slightly arched to nearly straight, a pronounced lateral thickening appearing near the upper edge about midway along the denticles. The very shallow excavation (escutcheon) beneath or slightly in front of the cusp, bounded on either side by knob-like expansions and with slight grooves extending anteriorly and posteriorly to disappear on the sharp keeled edges at the extremities of the base. Anterior limb of base with eight or more sharp stout denticles curving into approximate parallelism with the cusp. Posterior limb with six to eight or more sharp denticles essentially parallel to cusp. Cusp oblique to base, about twice as thick and one-third longer than the denticles, and usually wedged in on either side by immature denticles. The cusp and denticles laterally compressed and fused except for the very tips.

Syntypes.—B 4742, B 4746, B 4755; Geological Museum, University of Minnesota.

Occurrence.—187.

Cyrtoniodus? delicatus
Stauffer, n. sp.
Plate 51, figure 40

Base nearly straight, thin, with narrow groove. Cusp thin, laterally flattened, inclined to posterior at about 80°, followed by six or more denticles, which start as long slender ones near cusp but gradually decrease in length and increase in width tending more and more to a lower angle with bar. All denticles confluent half their length.

Holotype.—B 5082; Geological Museum, University of Minnesota.

Occurrence.—112.

CYRTONIODUS WORTHINGTONENSIS
Stauffer, n. sp.
Plate 51, figures 35, 41

Bar or base slightly arched, bowed inward at anterior, bowed outward and gradually tapering at posterior, with slight groove and probably slightly excavated beneath cusp. Upper edge set with about eight laterally compressed partly confluent major denticles, with small needlelike denticles between some of them. Cusp straight, laterally compressed, front edge extended below bar as slight spur.

Syntypes.—B 5077, B 5083, Geological Museum, University of Minnesota.

Occurrence.—187.

EUPRIONIODINA DORA
Stauffer, n. sp.
Plate 49, figure 9

Base broad, comparatively shallow, arched, keeled and with slight escutcheon just below or slightly posterior to base of cusp. Both outer and inner carinae well developed on anterior and extending to posterior limb. The outer is the more rounded. Anterior limb projects downward with about ten irregular, closely appressed sharp denticles curving into approximate parallelism with cusp. Denticles of posterior limb probably more numerous and more slender. Cusp well developed, slender, sharp pointed, sharp edged.

Holotype.—B 4783; Geological Museum, University of Minnesota.

Occurrence.—187.

EUPRIONIODINA SP. A
Plate 49, figure 20

In this specimen the cusp alone is preserved. It shows fracture surface, from which anterior downward projection is broken, and portion of posterior limb with bases of one or two denticles. Cusp slender, bending forward then curving back so tip is above base near origin of cusp. Cross section rounded, with outer and inner carinae slightly developed.

Figured specimen.—B 5086; Geological Museum, University of Minnesota.

Occurrence.—111.

EUPRIONIODINA SP. B
Plate 50, figure 32;
plate 52, figure 5

Bar nearly uniformly arched, sharply keeled, outer side flattened, inner with prominent rounded ridge, which is smooth throughout its length. Upper surface with irregular series of distinctly inserted denticles. Cusp entirely wanting on specimens available.

Figured specimens.—B 4826, B 4832; Geological Museum, University of Minnesota.

Occurrence.—112, 117.

EUPRIONIODINA? SP.
Plate 52, figures 2, 7

Fragmentary specimens belonging to various species, which are probably of the genus *Euprioniodina*. They cannot be identified specifically.

Figured specimens.—B 4927, B 4932; Geological Museum, University of Minnesota.

Occurrence.—111, 168.

FALCODUS INCULTUS
Stauffer, n. sp.
Plate 49, figure 10

Base of medium depth, rather thick, arched or bent downward posterior to cusp, keeled, with edge of inner carina nodose, outer carina poorly developed. Anterior limb with ten or twelve variable partly confluent denticles, several near the anterior rivaling the cusp in size. Posterior limb fragmentary but apparently having six or more partly confluent denticles decreasing in size posteriorly. Cusp slightly larger than adjacent denticles but not very distinctive.

Holotype.—B 4784; Geological Museum, University of Minnesota.

Occurrence.—111.

FALCODUS SP.
Plate 51, figure 23

Fragmentary specimen which seems to belong to anterior portion of species of this genus. It cannot be definitely identified, but illustration serves to indicate the

presence of this or similar genus in the fauna.

Figured specimen.—B 4919; Geological Museum, University of Minnesota.

Occurrence.—187.

GYROGNATHUS CARINATUS
Stauffer, n. sp.
Plate 51, figure 12

Base highly arched, posterior portion slightly twisted, flattened on under side, prominent shallow pit beneath cusp. Anterior limb thick but tapering rapidly to blunt point, four large denticles rivaling cusp, the third from cusp being largest. These all appear to be straight, tapering rapidly to points. Posterior limb thinner but probably longer, with set of small denticles, four being preserved. All denticles stocky and circular in cross section but cusp is slender, elongate, lenticular in cross section, with sharp cutting edges, curving sharply inward from base.

Holotype.—B 5063; Geological Museum, University of Minnesota.

Occurrence.—112.

HIBBARDELLA? SP.
Plate 49, figure 24

Base thin, arched. Adjacent to cusp there extends along upper margin of either limb a series of long slender denticles so closely crowded they may produce a scalloped curve at their tips. On one side, probably the posterior, very fine needlelike denticles alternate with larger ones. All diverge from axis of cusp. Long slender cusp at crest of arch, flattened on inner side, rounded on outer, inclining slightly to posterior.

Figured specimen.—B 4909; Geological Museum, University of Minnesota.

Occurrence.—187.

HINDEODELLA BETA
Stauffer, n. sp.
Plate 50, figures 16, 19

Bar slightly bowed, keel broad with a longitudinal groove. Anterior limb almost entirely wanting on specimens so far obtained, but small fragment shows it was bowed inward. Posterior limb nearly as wide as deep, oval in cross section, with the double series of denticles, one larger alternating with two or three to five thin, bladelike, smaller ones. Larger denticles with diameter in cross section almost as great as width of rather broad upper surface of bar. Cusp stout, slightly curved backward, not quite parallel with denticles.

Syntypes.—B 4816, B 4819; Geological Museum, University of Minnesota.

Occurrence.—112, 117.

HINDEODELLA CONFERTA
Stauffer, n. sp.
Plate 50, figures 21, 22

Bar slightly bowed, keeled, laterally compressed. Anterior limb fragmentary but bends slightly down and curves gently inward, set with a number of small denticles, some apparently larger and probably maintaining the alternating series. Posterior limb tapering gradually to a point. The larger series of denticles placed singly, more or less equally spaced, alternating with usually six to eight closely crowded, small sharp, needlelike denticles. Cusp relatively small and similar to one of denticles of larger series.

Syntypes.—B 4821, B 4822; Geological Museum, University of Minnesota.

Occurrence.—118, 120.

HINDEODELLA FISHINGERENSIS
Stauffer, n. sp.
Plate 50, figures 12, 33

Bar thick, nearly straight but slightly bowed or twisted, bluntly keeled. Anterior limb fragmentary but shows several small denticles and both a downward and inward curvature. Only about two-thirds of posterior limb present except in separate fragments, but following the cusp there is first a group of about eight small denticles of irregular size and then the double series, alternating one large and one small denticle. All are crowded at their bases and making angles of about 45° with the bar. Cusp straight, slightly compressed. The best specimen is weath-

ered white, but the other shows denticles distinctly inserted.

Holotype.—B 4812; figured specimen, B 4793; Geological Museum, University of Minnesota.

Occurrence.—117, 164.

HINDEODELLA LAMBTONENSIS
Stauffer, n. sp.
Plate 50, figures 2, 5, 8, 13, 14, 17, 20, 25, 28, 31

Bar elongate, slightly bowed and twisted, keeled, with two faintly marked lateral carinae slightly distant from keel. Much of anterior limb wanting on specimens in hand, but it bends down, curving inward, with a series of unequal denticles. Posterior limb with large denticles unequally spaced, alternating with groups of two to eight small ones. Denticles of both large and small series are of unequal sizes, all distinctly inserted and confluent as they emerge from bar. Cusp relatively large, flattened on outer side, its edges in line with first denticles of anterior limb but parallel to those on posterior limb. The method of growth or addition is probably by development at the posterior end, where five or six crenulations occur on various specimens.

Syntypes.—B 4802, B 4805, B 4808; figured specimens, B 4813, B 4814, B 4817, B 4820, B 4825, B 4828, B 4831; Geological Museum, University of Minnesota.

Occurrence.—111, 168, 180, 169, 187, 176, 120, 175.

HINDEODELLA MILLERI
Stauffer, n. sp.
Plate 50, figures 1, 3a, 3b, 4, 9–11

Bar long, slender, tapering to posterior, slightly bowed orally, keeled with slight flattening or small pit beneath cusp. Anterior limb short, curved slightly downward and abruptly inward, with a number (usually seven to ten) of crowded denticles, more or less irregular but tending to alternate a large with several small ones. Posterior limb with double series of slender sharp denticles, the larger ones standing singly, alternating with one to seven very small denticles. Cusp slender, slightly flattened, may be gently curved, parallel to denticles of posterior but making about a 40° angle with those of anterior limb. Cusp and denticles distinctly inserted.

Syntypes.—B 4801, B 4803, B 4810; paratypes, B 4804, B 4809, B 4811; Geological Museum, University of Minnesota.

Occurrence.—112, 118, 110, 120, 168, 187.

HINDEODELLA MODESTA
Stauffer, n. sp.
Plate 50, figures 7, 23, 24a, 24b, 27, 30

Bar slender, slightly bowed, keeled, tapering toward posterior. Anterior limb fragmentary but shows a downward bend at cusp and remnants of several small denticles. Posterior limb bears a double series of denticles, one larger alternating with two or three, rarely four, smaller ones. The posterior denticles in all Hindeodellas tend to become horizontal but this is particularly noticeable in this species. Cusp slender, sharp pointed, parallel to adjacent denticles.

Syntypes.—B 4807, B 4823, B 4824a and b, B 4827, B 4830; Geological Museum, University of Minnesota.

Occurrence.—172, 104, 118, 187, 112.

HINDEODELLA PLUMATELLA
Stauffer, n. sp.
Plate 50, figures 15, 18

Bar thin, slender, nearly straight, slightly bowed, sharply keeled, tapering very gradually and then rather abruptly at posterior. Anterior limb very fragmentary but shows a slight downward bend and inward curve. Posterior limb essentially complete, with needlelike denticles in two series, one larger alternating with two or three to eight smaller ones. All are distinctly inserted. Some germ denticles show that apparently would never erupt. Cusp relatively large, inclined to bar at about 60°, parallel to denticles.

Syntypes.—B 4815, B 4818; Geological Museum, University of Minnesota.
Occurrence.—187.

HINDEODELLA PRISCILLA
Stauffer, n. sp.
Plate 50, figure 6

Bar slender, keel very poorly developed. Anterior limb thin, relatively deep, bending markedly downward from point immediately below cusp and curving inward about 90°. It bears five or six large denticles alternating with one to three small needlelike denticles. Those denticles at front are relatively large. Posterior limb long, nearly straight, width and depth about equal, the larger denticles alternating with three to six or more smaller ones. Cusp small, slender, tending to parallel posterior denticles.

Holotype.—B 4806; Geological Museum, University of Minnesota.
Occurrence.—120.

HINDEODELLOIDES ABNORMALE
Stauffer, n. sp.
Plate 51, figure 25

Posterior limb of base nearly straight, keeled, denticulated edge meeting cusp through a sharply deflected curve or loop thus throwing half a dozen small denticles out of line but bridging the gap by a callosity. Denticle next to cusp long, partially fused to edge of cusp, followed by the very small denticles on the curve and then the regular series. Close observation shows spaces between denticles of regular series are occupied by exceedingly small denticles that almost fail to erupt. Downward limb or anticusp tapers to a blunt point, its outer edge bearing a series of chiefly very small recumbent denticles, one nearest the cusp, however, being very long, slender and fused with cusp except at tip. Cusp with edges perpendicular to denticulated edge of posterior limb, well buttressed at base, long, tapering to point.

Holotype.—B 5070; Geological Museum, University of Minnesota.
Occurrence.—112.

HINDEODELLOIDES CYNTHIANA
Stauffer, n. sp.
Plate 51, figure 27

Base consists of posterior limb of about uniform width and thickness, keeled, upper surface a double series of closely packed denticles, one large and one small alternating. Cusp and downward extension or anticusp curve out of line with denticles of posterior limb. Cusp is part of group of three or four large denticles on downward limb and difficult to distinguish.

Holotype.—B 5072; Geological Museum, University of Minnesota.
Occurrence.—187.

HINDEODELLOIDES SP.
Plate 51, figure 36

Posterior limb fragmentary but appears to have been stout, keeled, set with alternately one large and about three small denticles. Anterior downward extension relatively small but with long slender denticles clinging so closely to anterior edge that they may never have erupted. On both edges of cusp denticles climb well up before erupting.

Figured specimen.—B 5078; Geological Museum, University of Minnesota.
Occurrence.—187.

ICRIODUS ARKONENSIS
Stauffer, n. sp.
Plate 52, figures 10, 15

Elongate, tapering, slightly bowed dental plates with wide flaring base and deep aboral excavation largest at the broader end. Liplike flare occurs on inner margin of base. Oral surface marked by low median ridge extending from end to end, on each side a marginal row of rounded dental nodes, which are tied in pairs across the center ridge by short lateral ridges. The dental node at rounded end is unpaired and largest.

Syntypes.—B 4935, B 4940; Geological Museum, University of Minnesota.
Occurrence.—162.

ICRIODUS CYMBIFORMIS?
Branson and Mehl
Plate 52, figures 11, 13

Icriodus cymbiformis BRANSON and MEHL, *1938*, Jour. Paleontology, vol. 12, p. 164, pl. 26, figs. 27–29.

Dental plates having long tapering base with wide rounded flange opposite the tip surrounding deeper and larger portion of basal cavity. Oral surface with narrow denticulated ridgelike portion extending its full length. Two additional rows of three to five or more, short widely spaced denticles extend from pointed end to about midway, where they terminate abruptly. Median ridge continues on, bearing four or five more partly fused denticles, suggesting the blade of *Polygnathus* but over the broadest part of base.

Figured specimens.—B4936, B4938; Geological Museum, University of Minnesota.

Occurrence.—104, 108.

ICRIODUS ELEGANTULUS
Stauffer, n. sp.
Plate 52, figures 26, 27

Dental plate viewed from oral surface slender, slightly bowed, arched from tip to tip. Base slightly expanded but deeply excavated. Oral surface with median row of small denticles, widely spaced except for two partially coalesced at larger end. Denticles of lateral rows rather large, widely spaced, alternating in position with median row.

Holotype.—B 4947; Geological Museum, University of Minnesota.

Occurrence.—110.

ICRIODUS EXPANSUS
Branson and Mehl
Plate 52, figures 12, 14, 16, 19, 20, 25, 33, 35

Icriodus expansus BRANSON and MEHL, *1938*, Jour. Paleontology, vol. 12, pp. 160, 161, pl. 26, figs. 18–21.

Dental plates elongate, wedge-shaped, slightly bowed or straight, with deeply excavated base and broad flaring rim around larger end. Oral surface flat or slightly arched, with median denticular ridge bounded on each side by rows of denticles, which stand opposite and are tied across, through a median denticle, by a lateral ridge. There are six to eight such yoked pairs with corresponding median denticles. One or two median denticles at larger end are free from such ties though they may be partially confluent.

Figured specimens.—B 4937, B 4939, B 4941, B 4943, B 4946, B 4952, B 4954; Geological Museum, University of Minnesota.

Occurrence.—175, 108, 105, 180.

ICRIODUS LATERICRESCENS
Branson and Mehl
Plate 52, figures 30–32, 34

Icriodus latericrescens BRANSON and MEHL, *1938*. Jour. Paleontology, vol. 12, pp. 164–165, pl. 26, figs. 30–37.

Dental plate elongate and tapering in oral view but with a lateral outer extension from larger or bulbose end. Underside expanded to include extension, thus forming a rude slender isosceles triangle, which is deeply excavated from tip to base, and whose shape may be distorted by great extension of the lateral process. Oral surface with four to eight or ten cross ridges from marginal rows of denticles, strongly developed across the weak median dental ridge, each set separated transversely by deep furrows. Oral surface of lateral extension is variously developed, may be smooth or ridgelike but usually has double row of stout denticles similar to marginal series on main part of plate.

Figured specimens.—B4949, B4950, B4951, B4953; Geological Museum, University of Minnesota.

Occurrence.—108, 152, 153.

Genus LIGONODINA Ulrich and Bassler, 1926

This genus is especially characterized by the "downward extension of the main cusp" bearing a series of denticles, which thus becomes a limb of the tooth

and as such is not always distinctly a continuation of the cusp but rather a portion of the denticle-bearing base itself. It thus happens that teeth differing greatly from the genotype are included in the genus.

LIGONODINA DUPLICATA
Stauffer, n. sp.
Plate 51, figure 2

Posterior limb slender, straight, with series of distantly spaced backwardly directed denticles, groove underneath passing into a deep narrow conical pit beneath cusp. Downward limb or anticusp broad, tapering, with series of small denticles decreasing in size downward. Cusp slender, tapering, starting at right angles to posterior limb and curving slightly backward.

Holotype.—B4836; Geological Museum, University of Minnesota.

Occurrence.—120.

LIGONODINA? ERRATICA
Stauffer, n. sp.
Plate 51, figure 10

Posterior limb of base nearly or quite straight, downward extension or limb nearly at right angles to it. Under side of limbs with broad furrows, becoming deep wide pit beneath cusp. Posterior limb bears four or more irregular discrete denticles; downward limb bears several. Cusp lenticular in cross-section, lateral edges sharp, somewhat offset laterally, curved or twisted at base. This specimen doubtfully referred to this genus.

Holotype.—B4844; Geological Museum, University of Minnesota.

Occurrence.—120.

LIGONODINA EVA Stauffer, n. sp.
Plate 51, figure 3

Posterior limb of base is a nearly straight or slightly arched bar with a broad shallow groove becoming a shallow pit beneath cusp and bearing a series of discrete denticles, smaller towards anterior and directed backwards at an angle of about 75°. Downward extension or limb slightly offset to outer side of base of cusp, tapering, twisted with edge outward, bearing one denticle, which curves abruptly into parallelism with cusp. Cusp strong, slightly compressed laterally, with sharp edge in front, rising vertically from base but curving rapidly into parallelism with denticles.

Holotype.—B4837; Geological Museum, University of Minnesota.

Occurrence.—120.

LIGONODINA FRANKLINENSIS
Stauffer, n. sp.
Plate 51, figures 5, 16

Bar slightly arched, very broadly grooved below, bearing series of discrete slightly compressed denticles inclined backward about 80°. Cusp large, long, laterally compressed, parallel to denticles at base, curving slightly inwards towards apex. Basal extension of cusp broken off but may curve outward and bear a few denticles.

Holotype.—B4839; paratype, B5065; Geological Museum, University of Minnesota.

Occurrence.—120, 187.

LIGONODINA sp. cf. L. HINDEI
Ulrich and Bassler
Plate 51, figure 9

cf. *Lignodina hindei* ULRICH and BASSLER, *1926*, U. S. Nat. Mus. Proc., vol. 68, p. 14, pl. 2, figs. 14–16.

Base consists of posterior limb and downward extension of cusp. This latter inclines to posterior and slightly inward, is denticulate and therefore probably becomes a true limb rather than part of cusp. Posterior limb straight, approximately circular in cross-section, bearing series of subequal discrete denticles. Downward limb or anticusp short, thick, tapering to point, with four upward-curving denticles on outer side, inner showing slightly depressed central groove. Cusp stout, slightly curved, edges nearly perpendicular to posterior limb.

Figured specimen.—B4843; Geological Museum, University of Minnesota.

Occurrence.—151.

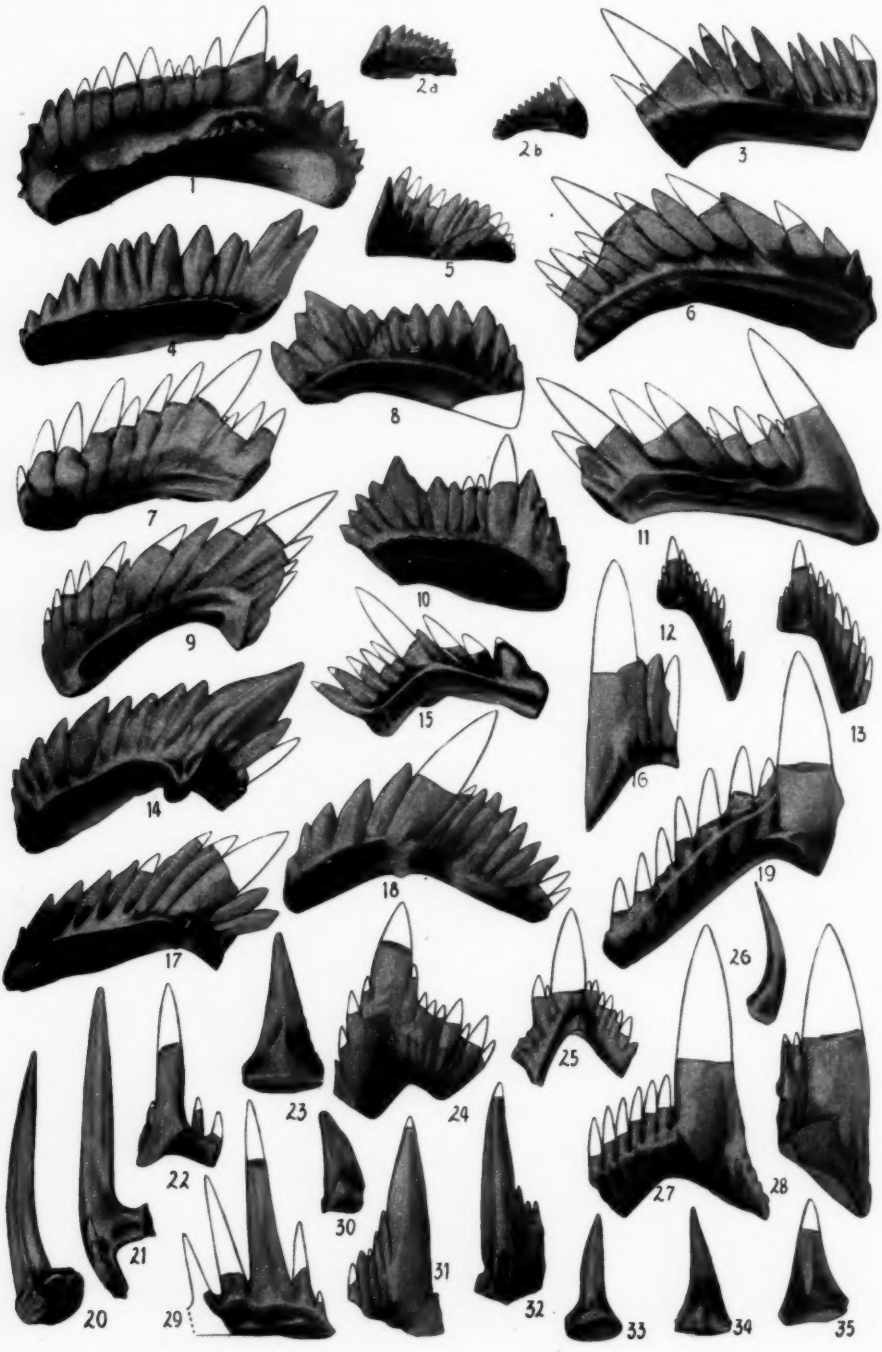
EXPLANATION OF PLATE 48

FIGS. *1, 5—Ctenognathus falcatus* Stauffer, n. sp. Syntypes: *1*, loc. 111; *5*, loc. 187. ×45 (p. 425)
2, 6, 15—Ctenognathus firmus Stauffer, n. sp. Syntypes: loc. 187. ×45. (p. 425)
3—Bryantodus imparilis Stauffer, n. sp. Holotype: loc. 120. ×45. (p. 423)
4, 7—Ctenognathus falsiformis Stauffer, n. sp. Holotype: *4*, loc. 121. Paratype: *7*, loc. 120 ×45. (p. 425)
8—Prioniodella insolita Stauffer, n. sp. Holotype: loc. 187 ×45. (p. 439)
9, 12—Ctenognathus elegans Stauffer, n. sp. Syntypes: *9*, loc. 120; *12*, loc. 118, ×45. (p. 424)
10, 13—Cervicornoides alternatus Stauffer, n. sp. Syntypes: *10*, loc. 120; *13*, loc. 104. ×45. (p. 424)
11—Bryantodus eriensis Stauffer, n. sp. Holotype: loc. 187. ×45. (p. 421)
14—Bryantodus concavus Huddle. Figured specimen: loc. 117. ×45. (p. 420)
16, 20—Bryantodus argutus Stauffer, n. sp. Holotype: *16*, loc. 187. Paratype: *20*, loc. 187. ×45. (p. 419)
17—Bryantodus stratfordensis Stauffer, n. sp. Holotype: loc. 111. ×30. (p. 423)
18, 19—Bryantodus amalitus Stauffer, n. sp. Syntypes: loc. 187. ×45. (p. 419)
21—Bryantodus sciotoensis Stauffer, n. sp. Holotype: loc. 120. ×45. (p. 422)
22, 24—Bryantodus grahami Stauffer, n. sp. Holotype: *24*, loc. 187. Paratype: *22*, loc. 187 ×45. (p. 421)
23—Bryantodus bellatulus Stauffer, n. sp. Holotype: loc. 187. ×45. (p. 419)
25—Nothognathella delawarensis Stauffer, n. sp. Holotype: loc. 111. ×45. (p. 436)
26, 31—Ctenognathus deparcus Stauffer, n. sp. Syntypes: loc. 109. ×45. (p. 424)
27, 28—Bryantodus olentangiensis Stauffer, n. sp. Syntypes: loc. 187. ×45. (p. 422)
29—Bryantodus dignatus Stauffer, n. sp. Holotype: loc. 112. ×45. (p. 420)
30—Nothognathella bogartensis Stauffer, n. sp. Holotype: loc. 112. ×45. (p. 436)
32—Bryantodus wesleyianensis Stauffer, n. sp. Holotype: loc. 187. ×45. (p. 423)
33—Bryantodus winchelli Stauffer, n. sp. Holotype: loc. 117. ×30. (p. 428)
34—Nothognathella angusta Stauffer, n. sp. Holotype: loc. 111. ×45. (p. 435)

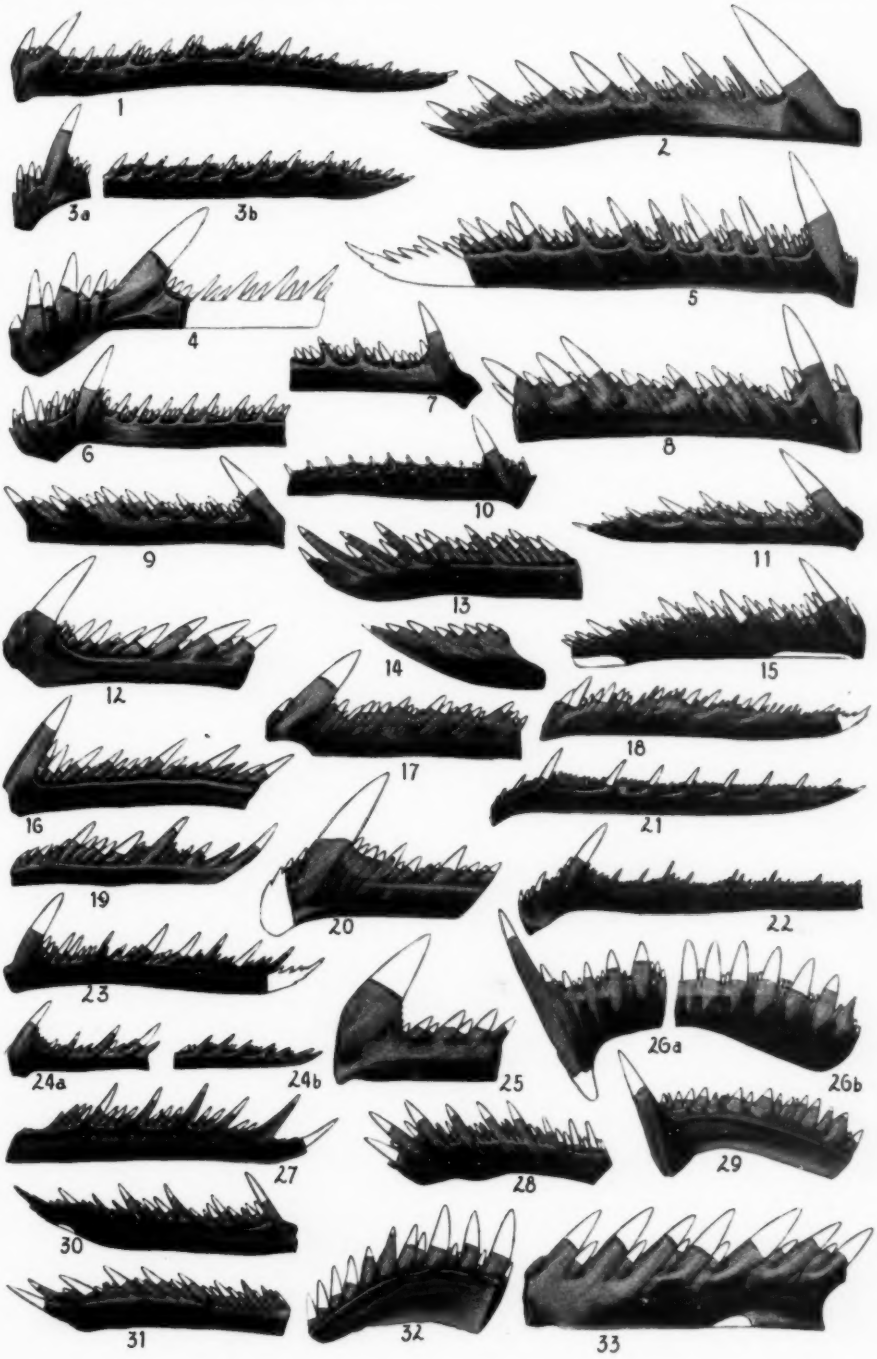
EXPLANATION OF PLATE 49

FIGS. *1, 4—Bryantodus prosseri* Stauffer, n. sp. Holotype: *1*, loc. 111. Paratype: *4*, loc. 112. ×45. (p. 422)
2a, 2b, 5—Polygnathus comis Stauffer, n. sp. Syntypes: loc. 187. ×45. (p. 438)
3—Bryantodus ignotus Stauffer, n. sp. Holotype: loc. 164. ×45. (p. 421)
6—Bryantodus stratfordensis Stauffer, n. sp. Paratype: loc. 187. ×45. (p. 423)
7—Bryantodus sublimatus Stauffer, n. sp. Holotype: loc. 111. ×30. (p. 423)
8—Bryantodus grahami Stauffer, n. sp. Paratype: loc. 187. ×45. (p. 421)
9—Euprioniodina dora Stauffer, n. sp. Holotype: loc. 187. ×45. (p. 426)
10—Falcodus incultus Stauffer, n. sp. Holotype: loc. 111. ×45. (p. 426)
11—Prioniodus? alpheus Stauffer, n. sp. Holotype: loc. 111. ×30. (p. 439)
12, 13—Synprioniodina gracilis Stauffer, n. sp. Syntypes: *12*, loc. 187; *13*, loc. 118. ×45. (p. 441)
14—Bryantodus nobilis Stauffer, n. sp. Holotype: loc. 112. ×30. (p. 422)
15—Bryantodus humboltensis Stauffer, n. sp. Holotype: loc. 108. ×30. (p. 421)
16—Prioniodus longidentatus Stauffer, n. sp. Holotype: loc. 120. ×30. (p. 441)
17—Bryantodus andersonensis Stauffer, n. sp. Holotype: loc. 120. ×45. (p. 419)
18—Bryantodus bryanti Stauffer, n. sp. Holotype: loc. 121. ×45. (p. 420)
19—Prioniodus idoneus Stauffer, n. sp. Holotype: loc. 111. ×45. (p. 440)
20—Euprioniodina sp. A. Figured specimen: loc. 111. ×30. (p. 426)
21—Lonchodina sp. Figured specimen: loc. 111. ×30. (p. 435)
22—Prioniodus affinis Stauffer, n. sp. Holotype: loc. 111. ×30. (p. 439)
23, 34, 35—Acodus inopinatus Stauffer, n. sp. Syntypes: *23, 34*, loc. 147; *35*, loc. 176. ×45. (p. 417)
24—Hibbardella? sp. Figured specimen: loc. 187. ×45. (p. 427)
25—Synprioniodina sp. Figured specimen: loc. 121. ×30. (p. 442)
26—Oistodus humilis Stauffer, n. sp. Holotype: loc. 147. ×45. (p. 436)
27—Prioniodus bownockeri Stauffer, n. sp. Holotype: loc. 116. ×30. (p. 440)
28—Plectodina stouti Stauffer, n. sp. Holotype: loc. 187. ×45. (p. 437)
29—Lonchodina inaequalis Stauffer, n. sp. Holotype: loc. 111. ×30 (p. 435)
30—Acodus zionensis Stauffer, n. sp. Holotype: loc. 147. ×45 (p. 417)
31, 32—Prioniodus sp. Figured specimens: loc. 187. ×45 (p. 441)
33—Acodus formosus Stauffer, n. sp. Holotype: loc. 147. ×45. (p. 417)

Stauffer, Devonian Conodonts



Stauffer, Devonian Conodonts



Stauffer, Devonian Conodonts

Stauffer, Devonian Conodonts

Explanation of Plate 50

Figs. *1, 3a, 3b, 4, 9–11—Hindeodella milleri* Stauffer, n. sp. Syntypes: *1*, loc. 118; *3a, 3b*, loc. 112; *10*, loc. 120. Paratypes: *4*, loc. 110; *9*, loc. 168; *11*, loc. 187. *1, 3a, 3b, 10* ×30; *4, 9, 11* ×45 (p. 428)

2, 5, 8, 13, 14, 17, 20, 25, 28, 31—Hindeodella lambtonensis Stauffer, n. sp. Syntypes: *2, 5*, loc. 111; *8*, loc. 168. Figured specimens: *13, 14, 20, 28*, loc. 187; *17*, loc. 169; *25*, loc. 176; *31*, loc. 120. *2, 5, 8, 17, 28, 31* ×30; others ×45. (p. 428)

6—Hindeodella priscilla Stauffer, n. sp. Holotype: loc. 120. ×45. (p. 429)

7, 23, 24a, 24b, 27, 30—Hindeodella modesta Stauffer, n. sp. Syntypes: *7*, loc. 172; *23*, loc. 104; *24a, 24b*, loc. 118; *27*, loc. 187; *30*, loc. 112. *23a, 23b* ×30; others ×45. (p. 428)

12, 33—Hindeodella fishingerensis Stauffer, n. sp. Holotype: *12*, loc. 117. Figured specimen: *33*, loc. 164. *12* ×30; *33* ×45. (p. 427)

15, 18—Hindeodella plumatella Stauffer, n. sp. Syntypes: loc. 187. ×45. (p. 428)

16, 19—Hindeodella beta Stauffer, n. sp. Syntypes: *16*, loc. 112; *19*, loc. 117. *16* ×45; *19* ×30. (p. 427)

21, 22—Hindeodella conferta Stauffer, n. sp. Syntypes: *21*, loc. 120; *22*, loc. 118. ×45. (p. 427)

26a, 26b—Prioniodus smithi Stauffer, n. sp. Holotype: loc. 187. ×45. (p. 441)

29—Prioniodus powellensis Stauffer, n. sp. Holotype: loc. 117. ×45. (p. 441)

32—Eupriomiodina sp. B. Figured specimen: loc. 117. ×45. (p. 426)

Explanation of Plate 51

Fig. *1—Tricognathus devonicus* Stauffer, n. sp. Holotype: loc. 104. ×45. (p. 442)

2—Ligonodina duplicata Stauffer, n. sp. Holotype: loc. 120. ×45. (p. 431)

3—Ligonodina eva Stauffer, n. sp. Holotype: loc. 120. ×45. (p. 431)

4—Bryantodus bennerensis Stauffer, n. sp. Holotype: loc. 108. ×30. (p. 420)

5, 16—Ligonodina franklinensis Stauffer, n. sp. Holotype: *5*, loc. 120. Paratype: *16*, loc. 187. *5* ×30; *16* ×45. (p. 431)

6—Tricognathus hoffmani Stauffer, n. sp. Holotype: loc. 174. ×45. (p. 442)

7—Lonchodina disjuncta Stauffer, n. sp. Holotype: loc. 121. ×30. (p. 435)

8—Prioniodus? bifidus Stauffer, n. sp. Holotype: loc. 111. ×30. (p. 440)

9—Ligonodina sp. cf. *L. hindei* Ulrich and Bassler. Figured specimen: loc. 151. ×45. (p. 431)

10—Ligonodina? erratica Stauffer, n. sp. Holotype: loc. 120. ×30. (p. 431)

11—Cervicornoides heterodentatus Stauffer, n. sp. Holotype: loc. 153. ×45. (p. 424)

12—Gyrognathus carinatus Stauffer, n. sp. Holotype: loc. 112. ×20. (p. 427)

13, 28, 33—Plectodina aculeata Stauffer, n. sp. Syntypes: *13*, loc. 112; *28*, loc. 118; *33*, loc. 168; *13* ×30; others ×45. (p. 437)

14—Bryantodus? bezoensis Stauffer, n. sp. Holotype: loc. 112. ×30. (p. 420)

15, 24, 29—Plectodina armata Stauffer, n. sp. Syntypes: *15*, loc. 121; *24*, loc. 118; *29*, loc. 111. *15* ×30; others ×45. (p. 437)

17—Ligonodina sp. A. Figured specimen: loc. 165. ×45. (p. 434)

18, 20—Ligonodina sp. B. Figured specimens: *18*, loc. 121; *20*, loc. 111. ×30. (p. 434)

19—Bryantodus ausablensis Stauffer, n. sp. Holotype: loc. 180. ×45. (p. 419)

21a, 21b—Plectodina sp. Figured specimen: loc. 167. ×45. (p. 437)

22—Cardiodus? leviculus Stauffer, n. sp. Holotype: loc. 153. ×45. (p. 423)

23—Falcodus sp. Figured specimen: loc. 187. ×45. (p. 426)

25—Hindeodelloides abnormale Stauffer, n. sp. Holotype: loc. 112. ×45. (p. 429)

26—Ligonodinoides ohioensis Stauffer, n. sp. Holotype: loc. 120. ×45. (p. 434)

27—Hindeodelloides cynthiana Stauffer, n. sp. Holotype: loc. 187. ×45. (p. 429)

30, 32, 34, 42—Ligonodinoides welleri Stauffer, n. sp. Holotype: *32*, Loc. 111. Paratypes: *30, 34, 42*, loc. 187. ×45. (p. 435)

31, 37–39—Ligonodinoides lewisensis Stauffer, n. sp. Syntypes: *31, 37*, loc. 187. Paratypes: *38*, loc. 187; *39*, loc. 112. ×45. (p. 434)

35, 41—Cyrtoniodus worthingtonensis Stauffer, n. sp. Syntypes: loc. 187. ×45. (p. 426)

36—Hindeodelloides sp. Figured specimen: loc. 187. ×45. (p. 429)

40—Cyrtoniodus? delicatus Stauffer, n. sp. Holotype: loc. 112. ×45. (p. 425)

LIGONODINA sp. A
Plate 51, figure 17

Outer lateral view of a large fragment probably belonging to this genus. Posterior limb of bar is gone, but fracture face shows its position and probable direction. Downward extension or limb not quite continuing outer curvature of cusp, bearing three or four upwardly directed denticles. Cusp strongly developed, subcircular in cross section, showing basal excavation and abrupt posterior curvature above bar.

Figured specimen.—B5066; Geological Museum, University of Minnesota.

Occurrence.—165.

LIGONODINA sp. B
Plate 51, figures 18, 20

Two fragments of large somewhat different form. Posterior limb missing, but fracture shows it was large. Downward limb offset from base of cusp with edge turned outward and bearing seven or eight rather large backwardly curving denticles. Cusp well developed, large, and curving to posterior.

Figured specimens.—B5067, B5069; Geological Museum, University of Minnesota.

Occurrence.—111 and 121.

LIGONODINA? sp.
Plate 52, figures 1, 4, 6

Fragmentary specimens belonging to various species probably of the genus *Ligonodina*. They lack the most characteristic features and cannot be satisfactorily identified. They are illustrated to show the presence of such species in the fauna.

Figured Specimens.—B4926, B4934, B4933; Geological Museum, University of Minnesota.

Occurrence.—111, 120, 167.

Genus LIGONODINOIDES
Stauffer, n. gen.

Dental unit consists of long slender nearly straight or slightly bowed posterior limb closely set with laterally compressed denticles, whose sharp edges may be confluent at base. Downward extension of cusp or downward limb long, may be slightly curved to anterior; its outer or anterior edge bears series of denticles, which cling closely to edge of limb and tend to parallel cusp. Under side appears keeled, but one or both limbs may have narrow furrow. There may be very small pit below at juncture of limbs, but usually none is observable. Cusp laterally compressed, long, often slender, more or less parallel to denticles of posterior limb in some species, but usually slightly divergent to anterior. Adjacent denticles on either side have germ portion divergent from axis of cusp, but erupted parts have tendency to climb up edges of cusp, thus in some forms causing it to appear double or multiple. Several germ denticles may be incorporated into base of cusp even though not erupting.

Genotype.—Ligonodinoides ohioensis Stauffer, n. sp.

LIGONODINOIDES LEWISENSIS
Stauffer, n. sp.
Plate 51, figures 31, 37–39

Base consists of relatively narrow posterior limb, deep at cusp, tapering to posterior, keeled or very slightly grooved, upper edge bearing series of closely set compressed denticles with edges confluent in lower part. Two or three smaller denticles near cusp wedge into its base and erupt well up along its posterior edge. Downward limb or anticusp projects forward out of line with cusp, tapering, with two or three, possibly more, long slender denticles that cling closely to anterior edge and climb up cusp. Cusp long, slender, laterally compressed.

Syntypes.—B5074, B5079; paratypes, B5080, B5081; Geological Museum, University of Minnesota.

Occurrence.—112, 187.

LIGONODINOIDES OHIOENSIS
Stauffer, n. sp.
Plate 51, figure 26

Posterior limb slender, slightly bowed inward, upper edge closely set with small

denticles that increase in size from cusp toward posterior, with very narrow groove, which meets a similar but even less pronounced one from downward limb in an elusive pit beneath cusp. A long slender slightly curved downward limb bears on its anterior edge a series of seven or eight, possibly more, closely set denticles, which increase in size from cusp then decrease to lower end and cling to edge, tending to parallel cusp. Germ denticles faintly shown, but cusp appears to incorporate two, possibly three in its base. Cusp slender, long, nearly parallel to denticles of posterior limb.

Holotype.—B5071; Geological Museum, University of Minnesota.

Occurrence.—120.

LIGONODINOIDES WELLERI
Stauffer, n. sp.
Plate 51, figures 30, 32, 34, 42

Posterior limb of base deeper at cusp, gradually tapering to extremity, under side with narrow groove, which also affects downward limb after expanding into very slight cavity beneath cusp; slightly bowed, with eight or more similar closely set backwardly inclined denticles, which in some specimens erupt well up the posterior edge of cusp. Downward extension or limb tapering, about as long as cusp, with about half a dozen small closely clinging or partially erupted denticles. Cusp laterally compressed, slender, tapering to point, slightly curved inward.

Holotype.—B5075; paratypes, B5073, B5076, B5084; Geological Museum, University of Minnesota.

Occurrence.—112, 187.

LONCHODINA DISJUNCTA
Stauffer, n. sp.
Plate 51, figure 7

Base arched, slightly flattened laterally, pit beneath cusp long, deep and wide. Denticles on posterior limb rising nearly perpendicular to base, those of anterior curving backward, tending to parallel posterior denticles. Cusp strongly developed, slightly offset from apex of arch, extending parallel to posterior denticles. Cusp and denticles entirely discrete, more or less rounded in cross section.

Holotype.—B4841; Geological Museum, University of Minnesota.

Occurrence.—121.

LONCHODINA INAEQUALIS
Stauffer, n. sp.
Plate 49, figure 29

Bar nearly straight. Anterior limb, bearing two unequal discrete denticles, ends in blunt point, which curves slightly downward. Posterior limb fragmentary but probably nearly straight and longer than anterior; two rounded denticles preserved. Cusp slender, straight, slightly inclined to posterior, lenticular in cross-section with greater convexity on outer side.

Holotype.—B5089; Geological Museum, University of Minnesota.

Occurrence.—111.

LONCHODINA sp.
Plate 49, figure 21

This fragmentary specimen shows an excellent cusp but unsatisfactory portions of rest of tooth. Posterior limb fragmentary but shows it is well developed without denticles near cusp. Downward limb or extension bears three, possibly more, denticles. Posterior limb curves into base of cusp, which is only slightly curved above, being long, slender, tapering to a point, with one or two longitudinal grooves; cross section subcircular showing slight flattening in front.

Figured specimen.—B5088; Geological Museum, University of Minnesota.

Occurrence.—111.

NOTHOGNATHELLA ANGUSTA
Stauffer, n. sp.
Plate 48, figure 34

Base slightly arched and bowed, broad, relatively shallow, flattened beneath cusp but weakly keeled towards ex-

tremities. Outer margin with a rounded carina on anterior limb, becoming angular towards center, then expanding into a narrow shelf, which is papillose and widest just posterior to cusp. Inner carina develops into a broadly arched slightly papillose flange, widest just anterior to cusp. Anterior limb bears 13 or 14 laterally compressed; closely appressed denticles, confluent nearly to apices. Posterior limb with eight or ten much shorter but closely set stout denticles decreasing in size posteriorly. Cusp stout and well developed but scarcely distinguishable from the two succeeding anterior denticles.

Holotype.—B4774; Geological Museum, University of Minnesota.

Occurrence.—111.

NOTHOGNATHELLA BOGARTENSIS
Stauffer, n. sp.
Plate 48, figure 30

Base arched, rather stout, aboral keel well developed along anterior limb, poorly developed along posterior, excavation fairly well developed. Outer flange narrow, with rounded edges, extending along side as a thick ridge, disappearing towards ends. Inner flange much expanded just posterior to cusp and with surface papillose. Anterior limb with about twelve irregularly developed crowded sharp denticles; posterior with seven or eight, possibly more, small ones. Cusp small, sharply pointed.

Holotype.—B4770; Geological Museum, University of Minnesota.

Occurrence.—112.

NOTHOGNATHELLA DELAWARENSIS
Stauffer, n. sp.
Plate 48, figure 25

Base arched, deep on anterior limb, shallow on posterior; laterally carinate, the outer more pronounced and becoming flangelike near the cusp on posterior limb, the inner flangelike on anterior limb, papillate and developed into a real platform along cusp. Aboral surface with a broad keel, which becomes slightly flattened at center of arch. Anterior limb with perhaps six or more long laterally flattened denticles confluent throughout most of their length. Posterior limb with seven or eight, perhaps more, broad short denticles, confluent only at the very base. Cusp double.

Holotype.—B4765; Geological Museum, University of Minnesota.

Occurrence.—111.

OISTODUS HUMILIS
Stauffer, n. sp.
Plate 49, figure 26

Base merely the expanded lower portion of cusp in no way distinguished from it, with deep conical excavation extending third of way to tip. Cusp circular in cross-section except where slightly compressed at base, slightly curved, slender, tapering to point.

Holotype.—B5085; Geological Museum, University of Minnesota.

Occurrence.—147.

PALMATOLEPIS FLABELLIFORMIS
Stauffer, n. sp.
Plate 53, figures 2, 4, 9, 12, 14

Plate broad, lobate, thin, slightly concave but may be variously shaped. Under side showing concentric growth lines and pronounced carina extending from point of blade to sharp tip of plate but dipping into subcentral depression beneath cusp or center denticle; much less pronounced lateral keel branches from main one at pit, extending to prominent rounded marginal lobe. Oral surface with long denticulated blade extending into plate and continuing as denticulated ridge curving to large subcentral denticle, from which it extends nearly straight to sharp tip. Several specimens show a smooth secondary ridge originating in large subcentral denticle and extending to same marginal lobe that receives secondary carina below. Surface variously covered with small nodes, but these may be localized and parts may be smooth. Margin set with nodes, which tend to become transverse ridges or may be obsolete over portions of plate.

Syntypes.—B4956, B4958, B4963,

B4966, B4968; Geological Museum, University of Minnesota.

Occurrence.—111, 117, 187.

PALMATOLEPIS MARGINATUS
Stauffer, n. sp.
Plate 53, figures 3, 7, 8, 13, 17

Small thin delicate slightly arched or warped plates with rounded lobes. Under surface shows indistinct growth lines and sharp, thin carina extending from tip of blade with a sigmoid curve through small central depression to rounded point of plate. Oral surface with short blade lying almost wholly within plate where it forms curving dental ridge to subcentral cusp. From this a ridge, occasionally bearing a few denticles, extends to rounded point of plate. Subcentral denticle triangular in cross-section with two angles towards blade and tip of plate, the third towards large marginal lobe. General upper surface smooth or with exceedingly small scattered papillae.

Syntypes.—B4957, B4795, B4962, B4967, B4796; Geological Museum, University of Minnesota.

Occurrence.—187, 109, 110.

PLECTODINA ACULEATA
Stauffer, n. sp.
Plate 51, figures 13, 28, 33

Posterior limb of base strong, nearly uniform, grooved below, with series of small needlelike denticles. Downward limb thin, tapering to blunt point, with four or five needlelike denticles that tend to cling to edge and may not be easily distinguished from it. Cusp lenticular in cross-section, bending upward and forward parallel to posterior denticles, excavation in base small.

Syntypes.—B4917, B4918, B4923; Geological Museum, University of Minnesota.

Occurrence.—112, 118, 168.

PLECTODINA ARMATA
Stauffer, n. sp.
Plate 51, figures 15, 24, 29

Posterior limb of bar long, slender, with four or five, perhaps more, slightly compressed denticles; occasional small denticles may be intercalated and all incline forward at about 45°. Downward limb has edge with three or four small knoblike denticles, makes angle of about 60° with other limb and between them is a broad flaring plate covering part of the large deep basal excavation. Cusp laterally compressed, curving slightly inward.

Syntypes.—B4916, B4914, B4913; Geological Museum, University of Minnesota.

Occurrence.—111, 118, 121.

PLECTODINA sp.
Plate 51, figures 21a, 21b

Bar fragmentary but apparently nearly straight, grooved below, deeply excavated beneath cusp, with laterally compressed denticles confluent at base and one or two next to cusp never erupted. Cusp laterally compressed, broad at base, rapidly tapering to point, flattened faces curving rapidly at base but straightening out above; outer edge sharp, nearly straight or slightly curved, continuing into edge of downward extension. This latter tapers rapidly to a point and is probably without denticulation or with very small ones clinging closely to the edge. Even specimens having no apparent erupted denticles here may show several germ units in that position.

Figured specimen.—B4911; Geological Museum, University of Minnesota.

Occurrence.—167.

PLECTODINA STOUTI
Stauffer, n. sp.
Plate 49, figure 28

Bar fragmentary, but scar shows it deep and relatively thin. Denticles closely crowded, long, confluent except at tips. Cusp large, curving inward from base, expanded at base to enclose large conical pit, cross section lenticular, one edge confluent with adjacent denticles, the other sharp and descending below base as outer edge of extension.

Holotype.—B4908; Geological Museum, University of Minnesota.

Occurrence.—187.

POLYGNATHUS BASILICUS
Stauffer, n. sp.
Plate 53, figures 42, 43a, 43b

Plate elongate, laterally flexed towards posterior. Blade the dominant portion, set at an angle of about 150° to the plate, thin, keeled and set with 14 to 16, perhaps more, flattened denticles confluent except at tips, end marked by a sharp-pointed stout or sturdy denticle and a continuing series of diminishing sharp denticles extending over top of plate to posterior. Plate pointed at posterior, widening to beginning of blade then narrowing abruptly and extending along sides of blade as a ridge or carina nearly one third its length. Under surface of plate flattened but bearing a continuation of the keel of blade to its posterior tip.

Syntypes.—B4790, B4794; Geological Museum, University of Minnesota.

Occurrence.—109.

POLYGNATHUS COMIS
Stauffer, n. sp.
Plate 49, figures 2a, 2b, 5

Plate nearly straight or slightly arched, under side keeled in blade portion but widening out at pit and the posterior flattened. Blade thin, deep at anterior and diminishing in depth but extending through to posterior tip of plate. Denticles with fused edges, the anterior ones generally large and long but decreasing towards posterior. Plate poorly developed, beginning near center of tooth as a ridge or carina, which broadens into a plate that may be nodose on upper surface but nearly disappears at posterior.

Syntypes.—B4771, B4776, B4779; Geological Museum, University of Minnesota.

Occurrence.—187.

POLYGNATHUS DECOROSUS
Stauffer, n. sp.
Plate 53, figures 1, 5, 6, 10, 11, 15, 16, 20, 30

Plate very slightly arched, may be bowed with under side forming angular arch or flattened sigmoid curve; under side keeled, with shallow groove in top of keel on blade portion widening into shallow diamond shaped pit at wide end of plate. Blade strong, highly developed, upper surface set with 12 or more long, flattened, partly fused denticles, which continue into median ridge of plate and extend to its tip. Lateral furrows bounded by median ridge, outer margins deep and opening towards blade. Outer rows of denticles confluent with edges of plate.

Syntypes.—B4955, B4959, B4960, B4983; paratypes, B4964, B4965, B4969, B4970, B4974; Geological Museum, University of Minnesota.

Occurrence.—111, 187, 117, 168.

POLYGNATHUS SANDUSKIENSIS
Stauffer, n. sp.
Plate 53, figures 27, 36, 37

Plate thick, arched, bowed inward but never twisted. Under side rounded, smooth except for submedian keel that is furrowed along blade and has small lanceshaped pit one-third the distance along plate. Oral surface with short blade joining plate, its denticulated edge becoming submedian row of denticles in troughlike portion of plate between the high crenulated margins and disappearing at two-thirds the length of plate. Main surface features are cross ridges, which are interrupted by the median denticles and may degenerate into nodes on the short side. Apex of plate curved markedly inward. This species resembles *P. linguiliformis* Hinde but cannot be referred to any illustrations or descriptions of that species so far published. It is believed to be new but might grade into Hinde's species.

Syntypes.—B4981, B4989, B4990; Geological Museum, University of Minnesota.

Occurrence.—108, 165.

POLYGNATHUS STRONGI
Stauffer, n. sp.
Plate 53, figure 19

Plate arched, very slightly bowed, with strong high keel grooved from end

to end and in middle beneath wider end of plate flaring out into wide but shallow pit with thick outer margin. Oral surface with denticulated blade becoming median ridge of plate but essentially smooth in half towards point of plate. Surface of plate flattened, with row of nodes on either side just in from margin, which itself may be nodose. Furrows on either side of median ridge are uninterrupted and become deeper at broad or wide end of plate.

Holotype.—B4973; Geological Museum, University of Minnesota.

Occurrence.—108.

POLYGNATHUS WEBBI
Stauffer, n. sp.
Plate 53, figures 25, 26, 28, 29

Plate mildly arched, slightly bowed, keeled with small shallow pit, on either side of keel a ridge or carina. Oral surface with long denticulated blade entering median portion of plate and continuing as denticulated ridge to apex or point. Blade carries a dozen laterally flattened, partly confluent denticles and median ridge beyond varies, usually with a dozen or more denticles. Main feature of oral surface is cross ridging, which is interrupted throughout by median row of denticles, from which ridges radiate becoming ever more inclined to it toward point of plate. In some specimens these cross ridges may bifurcate or break up into papillae or nodes.

Syntypes.—B4980, B4982; paratype, B4979; Geological Museum, University of Minnesota.

Occurrence.—111, 117, 187.

PRIONIODELLA INSOLITA
Stauffer, n. sp.
Plate 48, figure 8

Base thick, highly arched without excavation (escutcheon) but keeled throughout, with pronounced ridges extending essentially the full length on either side near base of denticles and slightly higher at center of arch. Anterior limb bears 14 or 15, perhaps more, denticles, nearly uniform in size and united nearly their full lengths. Posterior limb with seven or eight, perhaps more, short nearly conical denticles not united above the base. All denticles nearly parallel and with slight posterior inclination. No very pronounced cusp present.

Holotype.—B4748; Geological Museum, University of Minnesota.

Occurrence.—187.

PRIONIODINA AVERSA
Stauffer, n. sp.
Plate 52, figure 3

Base thick, deep, slightly arched, a broad but distorted attachment surface on under side with a shallow pit beneath cusp. Anterior limb fragmentary but strong, with five straight denticles preserved; posterior with five or six similar but smaller denticles to point where the base rapidly tapers and bends abruptly down. This spurlike portion carries three small denticles. Cusp nearly straight, oval in cross-section, nearly at right angles to base.

Holotype.—B4787; Geological Museum, University of Minnesota.

Occurrence.—111.

PRIONIODUS AFFINIS
Stauffer, n. sp.
Plate 49, figure 22

Base slightly arched, posterior limb straight or nearly so, with series of discrete denticles circular in cross-section. Cusp curves inward, flattened on outer side, rounded on inner; lateral edges sharp, strongly buttressed at base, the very bottom of which flares on inner side to form a broad rounded spur. There are two denticles on inner basal edge of cusp.

Holotype.—B5087; Geological Museum, University of Minnesota.

Occurrence.—111.

PRIONIODUS? ALPHEUS
Stauffer, n. sp.
Plate 49, figure 11

Base thick, heavy, nearly straight except for a slight twisting and abrupt curve downward near the posterior; outer side with a broad rounded ridge,

inside a similar one much less pronounced. Under side a long lopsided attachment surface bounded by a lightly impressed inner lateral ridge and an outer one resembling a keel. Cusp terminal, followed by seven slightly compressed denticles of unequal size, then an eighth one, large and rivaling the cusp, is succeeded by four or five, possibly more, decreasing in size. Cusp keeled in front, its anterior edge extending downward below the bar as a short blunt spur. Cusp and all denticles sharp and directed posteriorly at nearly the same angle.

Holotype.—B4785; Geological Museum, University of Minnesota.

Occurrence.—111.

PRIONIODUS? BIFIDUS
Stauffer, n. sp.
Plate 51, figure 8

Base with posterior limb fragmentary but apparently straight, with small peglike denticles, only one of which is preserved, under side with broad groove extending into cavity beneath cusp. Cusp long, curving backward in lower part, then becoming straight and tapering gradually to point; cross-section biconvex, with carinate lateral edges extending downward into two sub-basal spurs that seem to replace the sub-basal limb or anticusp.

Holotype.—B4842; Geological Museum, University of Minnesota.

Occurrence.—111.

PRIONIODUS BOWNOCKERI
Stauffer, n. sp.
Plate 49, figure 27

Bar shows crowded rounded denticles deeply set, their lower ends penetrating nearly to keel. Cusp sharp edged, the anterior extending below bar into sharp-pointed inbowing anticusp, which bears half a dozen or more germ denticles that fail to erupt but crenulate the edge. Outer side of cusp flattened, inner side convex with rounded liplike inward projection at base. Cusp of this form also shows multiple germ denticle origin.

Holotype.—B5091; Geological Museum, University of Minnesota.

Occurrence.—110.

PRIONIODUS IDONEUS
Stauffer, n. sp.
Plate 49, figure 19

Bar slightly bowed outward, keeled but flattened and slightly excavated beneath cusp, bearing eight or more closely set peglike denticles, which incline forward. Cusp flattened, lenticular in shape, curved upward, anterior sharp edge continuing below base as anticusp.

Holotype.—B5093; Geological Museum, University of Minnesota.

Occurrence.—111.

EXPLANATION OF PLATE 52

FIGS. *1, 4, 6—Ligonodina?* sp. Figured specimens: *1*, loc. 167; *4*, loc. 120; *6*, loc. 111. ×30. (p. 434)

2, 7—Euprioniodina? sp. Figured specimens: *2*, loc. 111;, *7*, loc. 168. ×45. (p. 426)

3—Prioniodina aversa Stauffer, n. sp. Holotype: loc. 111. ×45. (p. 439)

5—Euprioniodina sp. B. Figured specimen: loc. 112. ×45. (p. 426)

8, 9—Ancyrognathus asteroideus Stauffer, n. sp. Holotype: loc. 110. ×45. (p. 418)

10, 15—Icriodus arkonensis Stauffer, n. sp. Syntypes: loc. 162. ×45. (p. 429)

11, 13—Icriodus cymbiformis? Branson and Mehl. Figured specimens: *11*, loc. 108; *13*, loc. 104. ×45. (p. 430)

12, 14, 16, 19, 20, 25, 33, 35—Icriodus expansus Branson and Mehl. Figured specimens: *12, 33, 35*, loc. 175; *14*, loc. 108; *16, 25*, loc. 105; *19, 20*, loc. 180. ×45. (p. 430)

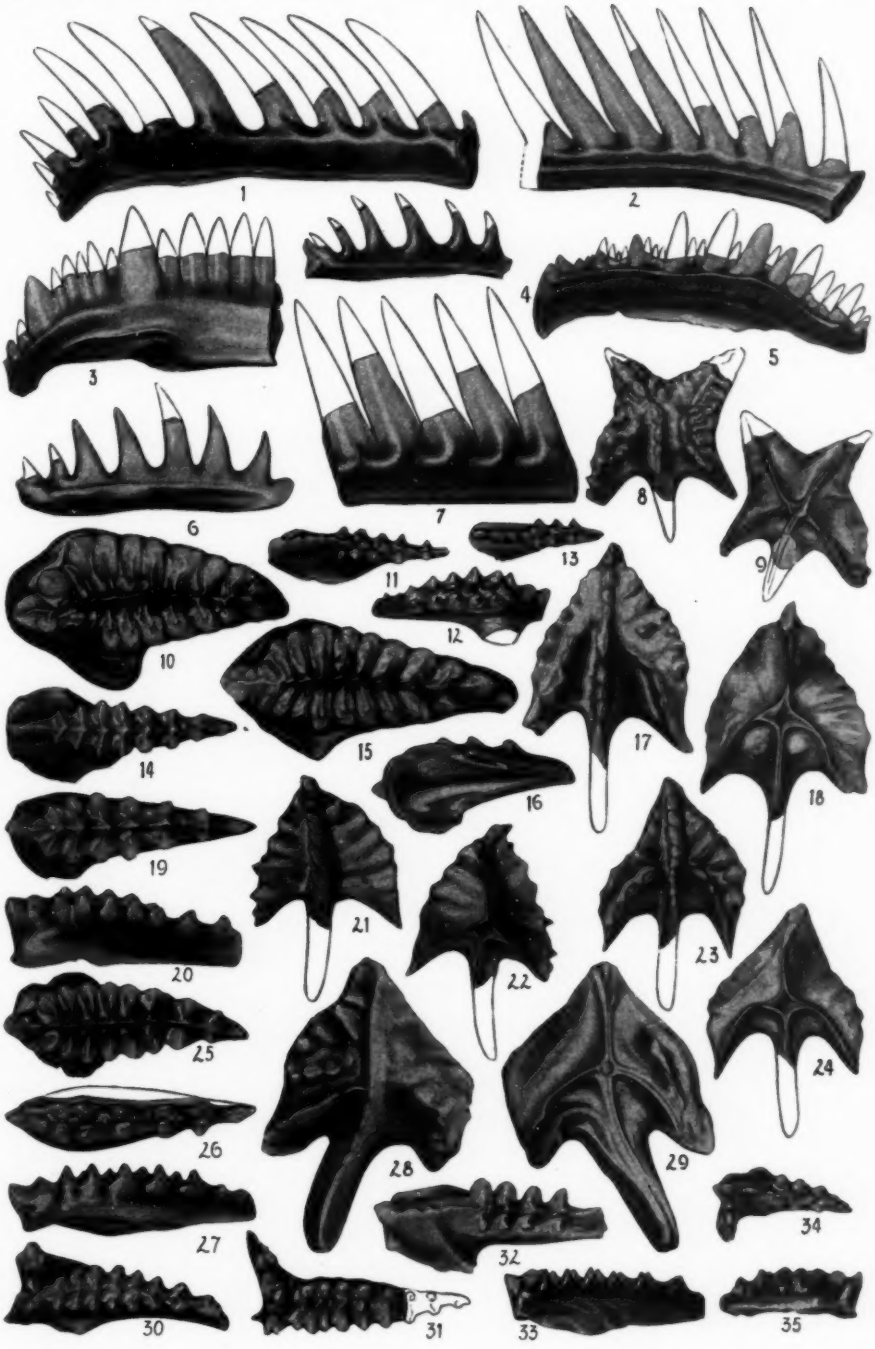
17, 18, 23, 24—Ancyrodella buckeyensis Stauffer, n. sp. Syntypes: *17, 18*, loc. 112: *23, 24*, loc. 120. ×45. (p. 418)

21, 22—Ancyrodella plena Stauffer, n. sp. Holotype: loc. 112. ×45. (p. 418)

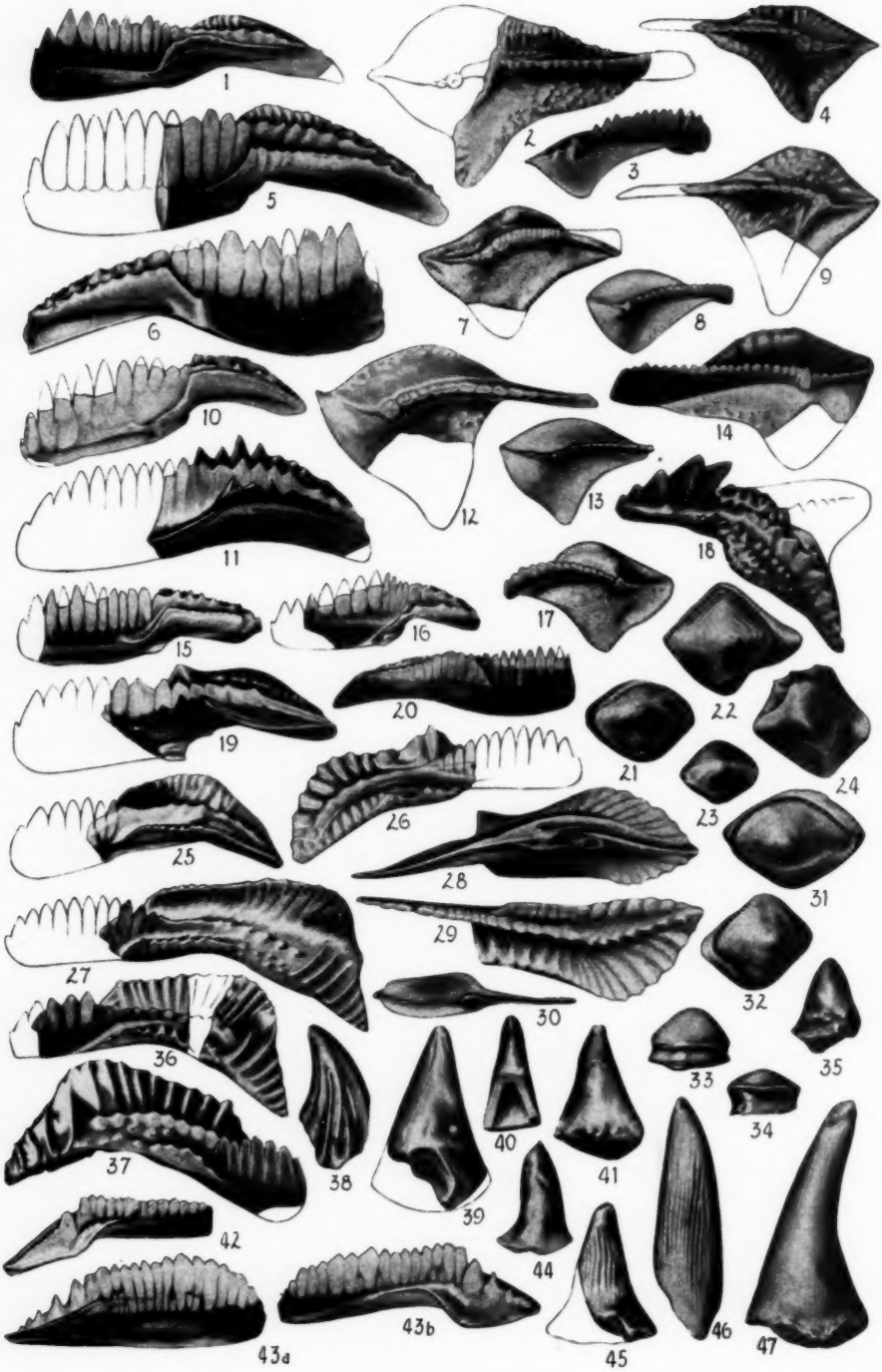
26, 27—Icriodus elegantulus Stauffer, n. sp. Holotype: loc. 110. ×45. (p. 430)

28, 29—Ancyrodella robusta Stauffer, n. sp. Holotype: loc. 110. ×45. (p. 418)

30–32, 34—Icriodus latericrescens Branson and Mehl. Figured specimens: *30*, loc. 153; *31, 34*, loc. 152; *32*, loc. 108. *30, 31* ×30; *32, 34* ×45. (p. 430)



Stauffer, Devonian Conodonts



Stauffer, Devonian Conodonts

PRIONIODUS LONGIDENTATUS
Stauffer, n. sp.
Plate 49, figure 16

Bar thin, shallow, probably straight, keeled, possibly slightly grooved, with series of long slender denticles confluent except at tips. Cusp long, straight, laterally flattened, bladelike; sharp anterior edge extends below bar into a short sharp-pointed anticusp. From suggestion of germ denticles in base of cusp it is probable that half a dozen or more take part in its development.

Holotype.—B5090; Geological Museum, University of Minnesota.

Occurrence.—120.

PRIONIODUS POWELLENSIS
Stauffer, n. sp.
Plate 50, figure 29

Bar slightly arched to nearly straight, bowed and curved inward at anterior so cusp is nearly at right angles to bar, under side keeled, with rounded ridge on each side midway between keel and denticles. Denticles numerous, closely set, of irregular sizes. Cusp terminal, large; outer edge projecting below bar as the basal extension.

Holotype.—B4829; Geological Museum, University of Minnesota.

Occurrence.—117.

PRIONIODUS SMITHI
Stauffer, n. sp.
Plate 50, figures 26a, 26b

Base or bar elongate, arched, slightly bowed, keeled on under side, upper edge bearing a double series of denticles, in which the larger alternate with one to three of the smaller. All denticles deeply set and with edges fused at base. Cusp slender, flattened, terminal, set inward out of line with and nearly at right angles to denticles. It extends somewhat below the bar and this downward extension bears several denticular nodes.

Holotype.—B4743; Geological Museum, University of Minnesota.

Occurrence.—187.

PRIONIODUS sp.
Plate 49, figures 31, 32

These are excellent cusps but bases are very poor. They resemble *Prioniodus longidentatus* described herewith, but probably are not that species; in fact these two probably represent different species.

Figured Specimens.—B4920, B4921; Geological Museum, University of Minnesota.

Occurrence.—187.

SYNPRIONIODINA GRACILIS
Stauffer, n. sp.
Plate 49, figures 12, 13

Bar long, slender, bowed inward, slightly grooved below with small cavity beneath cusp. Denticles small, needlelike, closely set but apparently discrete on posterior limb, inclined forward at about 45°. Posterior limb bears nine or ten denticles, possibly more, but short

EXPLANATION OF PLATE 53

FIGS. *1, 5, 6, 10, 11, 15, 16, 20, 30—Polygnathus decorosus* Stauffer, n. sp. Syntypes: *1, 30*, loc. 111; *5, 6*, loc. 187. Paratypes: *10*, loc. 117; *11*, loc. 168; *15, 16, 20*, loc. 187. *15* ×30; others ×45. (p. 438)

2, 4, 9, 12, 14—Palmatolepis flabelliformis Stauffer, n. sp. Syntypes: *2*, loc. 117; *4, 9, 12*, loc. 111; *14*, loc. 187. *2, 4, 9* ×30; *12, 14*, ×45. (p. 436)

3, 7, 8, 13, 17—Palmatolepis marginatus Stauffer, n. sp. Syntypes: *3, 8, 13*, loc. 187; *7*, loc. 109; *17*, loc. 110. *7* ×30; others ×45. (p. 437)

18—Ancyrognathus euglypheus Stauffer, n. sp. Holotype: loc. 112. ×30. (p. 418)

19—Polygnathus strongi Stauffer, n. sp. Holotype: loc. 108. ×45. (p. 438)

21–24, 31–34—Acanthodes? dublinensis Stauffer, n. sp. Syntypes: loc. 121. ×30. (p. 442)

25, 26, 28, 29—Polygnathus webbi Stauffer, n. sp. Syntypes: *26*, loc. 117; *28, 29*, loc. 187. Paratype: *25*, loc. 111. *25* ×30; others ×45. (p. 439)

27, 36, 37—Polygnathus sanduskiensis Stauffer, n. sp. Syntypes: *27*, loc. 165; *36, 37*, loc. 108. *27, 36* ×30; *37* ×45. (p. 438)

35, 38–41, 44–47—Fish teeth. Figured specimens: loc. 121. ×30. (p. 442)

42, 43a, 43b—Polygnathus basilicus Stauffer, n. sp. Syntypes: loc. 109. ×45. (p. 438)

downward extension only three. Cusp slender, circular or nearly so in cross-section, curving inward with anterior end of bar.

Syntypes.—B5094, B5095; Geological Museum, University of Minnesota.

Occurrence.—118, 187.

SYNPRIONIODINA sp.
Plate 49, figure 25

Fragment showing sharp or angular arch between to limbs, which meet at about 45°. Deep, narrow pit beneath cusp. Upper edges set with closely crowded denticles of somewhat variable size. Cusp elongate, flattened, edges sharp, surmounting top of arch.

Figured specimen.—B4912; Geological Museum, University of Minnesota.

Occurrence.—121.

TRICOGNATHUS DEVONICUS
Stauffer, n. sp.
Plate 51, figure 1

Posterior limb joining plane of lateral limbs at right angles, straight, showing about five denticles with smallest next to cusp, deep groove underneath passing into narrow deep subconical pit at arch formed by union of limbs. Lateral limbs apparently equal, each bearing series of small denticles, erect and parallel to cusp. Laterals formed as if by splitting cusp, the split still extending well into its base. Cusp with sharp lateral edges, slightly convex on anterior face and very convex on posterior, curving slightly backward, nearly perpendicular to posterior limb. Although fragmentary this specimen is quite distinctive.

Holotype.—B4835; Geological Museum, University of Minnesota.

Occurrence.—104.

TRICOGNATHUS HOFFMANI
Stauffer, n. sp.
Plate 51, figure 6

Base with strong straight posterior limb with peglike denticles and deep groove, which opens into deep pit beneath cusp; a small groove extends down inner and under side of larger member of arch. Members or limbs of arch bear short stout denticles in groovelike depressions along upper side of arch. Cusp thick, strongly buttressed at base, with rounded carinae on sides parallel with limbs of arch, cross section roundly oval with outer curvature greater than inner.

Holotype.—B4840; Geological Museum, University of Minnesota.

Occurrence.—174.

FISH TEETH
Plate 53, figures 35, 38–41, 44–47

Group of small conical teeth probably belonging to several species of primitive ganoid fishes. Some have smooth surfaces, some are longitudinally striate, others ribbed or carinate. They occur with conodonts in base of the shales just above the limestones. Many are pyritized.

Figured specimens.—B4988, B4991, B4992, B4993, B4994, B4997, B4998, B4999, B5096; Geological Museum, University of Minnesota.

Occurrence.—121.

ACANTHODES? DUBLINENSIS
Stauffer, n. sp.
Plate 53, figures 21–24, 31-34

More or less mushroomshaped scutes or dermal units with flaring attachment base, short constricted neck and high rounded cap. General outline from above is square or rhomboid, cap or upper surface rising to rounded four-sided truncated pyramid. Some show concentric lines on upper surface.

Although evidently not conodonts, these specimens occur with them and perhaps deserve recognition here. Most of them have been replaced by pyrite.

Syntypes.—B4975, B4976, B4977, B4978, B4984, B4985, B4986, B4987; Geological Museum, University of Minnesota.

Occurrence.—121.

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NEW DEVONIAN FOSSILS FROM CALHOUN COUNTY, ILLINOIS

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ABSTRACT

An 8-foot bed of hard light-gray limestone at the base of the Devonian system near Kritesville, Illinois, contains a fauna unlike any other reported from Illinois but having very obvious affinities with the upper (West Brook) member of the Tully limestone of New York. It and the overlying thin-bedded fossiliferous limestone appear to be equivalent to the upper part of the Cedar Valley limestone of Iowa. The evidence indicates a correlation of the Tully with the Partridge Point formation of Michigan and with the upper Cedar Valley of Illinois and Iowa. Fifteen new brachiopods and four new trilobites are described.

In July, 1936, we set out to study Middle Devonian strata of the Midwest. Among our objectives were the Devonian exposures of Calhoun County in west-central Illinois as well as the better known area of Devonian outcrop in southwestern Illinois. Although the Devonian is well exposed in Calhoun County little is known of the details of its stratigraphy or its contained fossils. A brief account of these strata is given by Worthen (1), but few particulars are recorded. A still briefer account is given by Weller (2). Hardin and Brussels quadrangles in Calhoun County were recently surveyed by W. Rubey (3) in cooperation with representatives of the Illinois Geological Survey. The Devonian rocks were mapped and detailed sections of the strata prepared. No attempt was made, however, to determine the sequence and relationships of the faunas, although fossils were collected. These were studied by Dr. T. E. Savage, who correlated the rocks containing them with the Cedar Valley limestone of Iowa (3).

Our purpose in visiting Calhoun County was to determine the sequence of Devonian strata and their contained faunas. Mr. Rubey kindly directed us to the exposures most likely to facilitate our studies. In collecting from one of these sections we discovered a fauna containing the trilobite *Scutellum* (formerly *Goldius*), which is unlike any other fauna reported from Illinois. Because of its affinities with the Tully fauna of New York, we regard this fauna as of sufficient importance in Devonian stratigraphy to require special notice.

The fossils described below were found at the base of the Devonian section in the first hollow south of Kritesville about one-half mile east of the road from Hamburg to Batchtown, SE ¼ NE ¼ section 20, T. 11 S., R. 2 W., Hardin quadrangle, Illinois. A Devonian interval of 40 feet was estimated by Mr. Rubey at this place. The lowest Devonian exposed consists of 8 feet of light-gray hard limestone containing *Scutellum* and other fossils. Above these are yellowish platy, thin-bedded limestones containing large *Schizophoria*, *Spirifer wortheni* Meek and Worthen, *Leptostrophia*, *Stropheodonta* and a few other species. The yellow color of the strata and the fossils contained in them are suggestive of the Cedar Valley limestone of Iowa.

Besides the locality mentioned above we visited four other exposures of the Devonian. None of these yielded any trace of the fauna with *Scutellum*, but the position of the fauna was clearly indicated although the beds containing it

are apparently absent. In Salt Spring Hollow, about two miles north of the hollow south of Kritesville, yellowish limestone containing *Schizophoria* is near the base of the section, indicating that the rocks containing the *Scutellum* fauna lie between the Cedar Valley of Calhoun County and the underlying Silurian Sexton Creek limestone.

FAUNA NEAR KRITESVILLE

Coelenterata
Heliophyllum sp.
Bryozoa
Cystodictya sp.
Fistulipora sp.
Brachiopoda
Douvillina bellistriata Cooper and Cloud, n. sp.
Stropheodonta sp.
Pholidostrophia sp.
Schuchertella sp.
Productella navicella Hall
Productella sp.
Pentamerella liorhyncha Cooper and Cloud, n. sp.
P. liorhyncha liorhynchoidea Cooper and Cloud, n. var.
Cranaena subcylindrica Cooper and Cloud, n. sp.
C. romingeri (Hall)
C. tinctaradiata Cooper and Cloud, n. sp.
C. amygdaloidea Cooper and Cloud, n. sp.
C. radiata Cooper and Cloud, n. sp.
C. myriopunctata Cooper and Cloud, n. sp.
C. sp.
Atrypa sp.
Meristella parva Cooper and Cloud, n. sp.
"*Spirifer*" sp. 1.
"*S.*" sp. 2.
Elytha sp. aff. *E. fimbriata* (Conrad)
Cyrtina sp.
Pelecypoda
Phthonia sp.
Palaeoneilo n. sp. cf. *P. constricta* (Conrad)
Nuculites sp. cf. *N. oblongatus* (Conrad)
N. nasutus Cooper and Cloud, n. sp.
Leptodesma minutum Cooper and Cloud, n. sp.
Conocardium bellum Cooper and Cloud, n. sp.
C. sp.
Actinoptera brevialata Cooper and Cloud, n. sp.
Lyriopecten illinoisensis Cooper and Cloud, n. sp.
L. sp.
Cypricardinia sp. cf. *C. indenta* (Conrad)
Modiomorpha sp.
Mytilarca? sp.
Gastropoda
Platyceras sp.
Cephalopoda
Acleistoceras ;)
Trilobita
Dechenella elevata Cooper and Cloud, n. sp.
Cornuproetus calhounensis Cooper and Cloud, n. sp.
Cordania pulchra Cooper and Cloud, n. sp.
Scutellum tullium depressum Cooper and Cloud, n. var.

A study of this faunal list and the illustrations of the species will indicate at once that the fauna has very obvious relationships to the West Brook or upper member of the Tully limestone. *Douvillina bellistriata* is closest to *D. inaequistriata* (Conrad), which is common in the upper Tully. The two pentamerellas belong to the same tribe as *P. pavilionensis*. *Lyriopecten illinoisensis* is close to *L. exacutus* (Hall); *Dechenella elevata* suggests *D. rowi* (Green); *Cordania pulchra* is related to *C. ornata* (Hall), which is occasionally found in the West Brook member. But of all the species indicating Tully age, *Scutellum tullium depressum* is the most important. This variety differs from *S. tullium* in minor details only.

Although the hollow south of Kritesville is the only locality of the five visited by us in Calhoun County where the fauna with *Scutellum* was seen, its position relative to other strata in the sequence can be determined in Salt Spring Hollow, where a complete section of the Devonian is visible. This section is along a small stream from the south about one mile and a quarter east of the Hamburg-Batchtown road in NE ¼ NW ¼ sec. 16, T. 11 S, R. 2 W. The section is as follows:

Section in Salt Spring Hollow

	Feet
D. Hard sugary sandstone abounding in fossils: *Schizophoria, Atrypa, Stropheodonta, Athyris Cranaena, asper* type of "*Spirifer*"	1
C. Massive light-gray granular crinoidal limestone with *Atrypa, Pholidostrophia, Cyrtina, Stropheodonta* and corals	13
B. Shaly-weathering, light- to yellow-gray cherty limestone with *Schizophoria, Leptostrophia, Cranaena, Pentamerella, Stropheodonta, Schuchertella, hystrix* type of *Atrypa*	13
A. Hard bluish to yellow-gray limestone, no fossils found	1
Silurian limestone?	

The bed labelled B in the above section is the same as the yellowish limestone that overlies the beds carrying the *Scutellum* fauna exposed near the spring in the hollow below Kritesville. It is possible that the beds in Salt Spring Hollow assigned to the Silurian may actually represent the *Scutellum* layers. We found no fossils in these, but the Silurian in this region does not abound in fossils.

Correlation of this section with the Cedar Valley beds of Iowa is difficult, and our remarks must be regarded as tentative. According to our view the entire section in Calhoun County is to be correlated with the *Atrypa waterlooensis* zone of the upper Littleton member and the lower part of the Coralville member near the top of the Cedar Valley (4). Coralville affinities of the uppermost sandstone of the Calhoun section are to be seen in the abundance of *Cranaena*. The fauna of bed B suggests the *bellula* zone of the Littleton member, but the added presence of *Pentamerella* and *Cranaena* like *C. iowensis* indicate a later Littleton age.

Although the *Scutellum* fauna is suggestive of the New York Tully, some of its species are also related to those in the Iowa section. Species of *Cordania*, *Dechenella*, *Cornuproetus*, *Pentamerella* and *Cranaena romingeri* recall some of the members of the Coralville fauna found at Mid River, Iowa. The available evidence all points to an upper Cedar Valley age for all of the Calhoun County beds. If the suggested correlations be correct, basis for determining the age of this part of the Cedar Valley in reference to New York and Michigan is established.

Although Weller (5) and Thomas (6) correlated the lower Cedar Valley limestone or Linwood member, which contains *Hypothyridina*, with the Tully, our evidence indicates that the Tully correlates rather with the upper Cedar Valley only. The presence of *Hypothyridina* in the lower Cedar Valley suggests a correlation with the lower Tully, which also contains *Hypothyridina*. But it must be borne in mind that the lower Cedar Valley contains other fossils, such as *Newberria*, which tend to link the Linwood with either the high Middle Devonian or the *Stringocephalus* horizon. We therefore regard a correlation of the lower Cedar Valley with the Tully limestone as untenable.

The correlation of the upper Cedar Valley with the Tully is also supported in Michigan. Here the *Stereocrinus* beds of the upper Traverse (Partridge Point formation) may be correlated with the *waterlooensis* zone of the Upper Littleton member of the Cedar Valley by virtue of the common presence of *Stereocrinus*. Beds equivalent to the Partridge Point formation north of Norwood on the Lake Michigan shore contain *Scutellum tullium depressum*. The position of these beds and the Partridge Point formation is clearly indicated as high Middle Devonian. They underlie the Squaw Bay (Middle Naples) limestone fauna on both sides of the lower peninsula of Michigan. The data mentioned thus indicate a correlation of the Tully of New York with the Partridge Point formation of Michigan and the latter with the upper Cedar Valley of Illinois and Iowa.

SYSTEMATIC DESCRIPTIONS

BRACHIOPODA

Twelve genera of brachiopods representing 20 species were found in the *Scutellum* fauna. The material of five of these genera, *Pholidostrophia*, *Schuchertella*, *Elytha*, *Cyrtina*, and *Atrypa*, is not sufficient or is too poorly preserved to describe. Specimens of *Cranaena* are the most numerous of the brachiopods and present the greatest number of species.

DOUVILLINA BELLISTRIATA Cooper and Cloud, n. sp.

Plate 54, figures 52, 58, 59

Shell of about medium size for the genus, strongly concavo-convex, wider

than long, with the greatest width at the hinge. Cardinal extremities slightly alate. Anterior margin broadly rounded.

Beak of the ventral valve incurved, umbo swollen; median region of the valve full with flat and moderately steep lateral slopes. The dorsal valve is sulcate just anterior to the beak, the sulcus extending to about the middle of the valve. The greatest concavity is at about the middle.

The surface is ornamented by costellae of unequal size. Three generations of strong costellae appear by implantation anterior to the beak. The spaces between these are marked by fine radial threads, which are crossed by finer concentric lines to form a finely cancellated pattern. Dimensions of syntype U. S. N. M. 95170a: length, 10 mm; width, at middle, 12 mm; width of hinge, 13.5 mm.

Remarks.—This species is represented by 25 specimens. It differs from the larger *D. inaequistriata* (Conrad) of New York in its greater convexity, in having fewer and more irregularly spaced fine radial threads, and in its generally more delicate ornamentation.

Figured syntypes.—U. S. N. M. 95170a, b; unfigured syntypes, 95170c–e.

STROPHEODONTA sp.

Shell of about medium size for the genus; concavo-convex, wider than long, with the greatest width at the hinge. Cardinal extremities mucronate in the young, become alate in adults. Convexity of ventral valve moderate with the umbo strongly swollen. The dorsal valve is slightly concave with the greatest concavity a little anterior to the umbo.

Surface of both valves covered by costellae of unequal size. The umbo of the ventral valve is marked by strong angular more or less distant costellae appearing in at least three generations. Anteriorly these costellae become less prominent, and between them on all parts of the valve are several exceedingly fine radial threads. These and the costellae are crossed by fine concentric lines, which cancellate the intercostellar threads. The dorsal valve is marked in the umbonal region by radial threads of two sizes, the larger ones occupy shallow radial depressions, which correspond to the costellae of the ventral valve. The finer threads occupy the spaces between the larger ones. The umbonal region is finely wrinkled.

Remarks.—This genus is represented by three fragmentary adults and two immature specimens, U. S. N. M. 95211a–f. The whole lot is inadequate and too poorly preserved for the erection of a new species. The specimens belong to the *Stropheodonta concava* group and differ from Hamilton and Tully examples of that species in the lesser concavity of the dorsal valve and in the more delicate nature of the ornamentation.

PHOLIDOSTROPHIA sp.
Plate 54, figure 39

Poor material of a variable species of this genus is fairly common. Figured specimen, U. S. N. M. 95185.

PRODUCTELLA NAVICELLA Hall
Plate 54, figures 22, 23

A few specimens having the narrow form of this species were collected. Figured specimen, U. S. N. M. 95186a.

PENTAMERELLA LIORHYNCHA
Cooper and Cloud, n. sp.
Plate 54, figures 31–34

Small for the genus, subpentagonal in outline, lenticular in lateral and end profiles, slightly longer than wide with the greatest width a little anterior to the middle. Anterior margin uniplicate. Dimensions: length of ventral valve, 16.1 mm; length of dorsal valve, 14.4 mm; width, 15.0 mm; thickness, 9.3 mm.

Ventral valve moderately convex, curvature moderate and even to umbo, which is strongly convex. Flanks marked by four costae. Sulcus shallow, originating near the umbo and containing two costae. Beak incurved; umbo smooth.

Dorsal valve slightly convex, curvature greatest at the umbo. Three strong

costae mark the wide fold. Dorsal costae all more prominent and more acute than the ones on the ventral valve.

Remarks.—The holotype, three other complete specimens, and seventeen separated valves represent this species. The ornamentation of the species is very variable. Small costae are intercalated between larger ones or a broad costa on one flank of the valve may be the equivalent of two costae on the opposite side. Short bifurcations at the front of the valve increase the number of costae along the margin. Two specimens show two broad costae forming the fold, but the usual number is three primary costae. The holotype exhibits a peculiar feature of the costation. Two primary costae occupy the sulcus, but the broad rib on the left side opposes the marginal furrow and costa on the right side of the sulcus. This same feature is shown in another complete specimen.

Pentamerella liorhyncha belongs to the same group as *P. arata* and *P. pavilionensis*, in which the costation is low, variable, and strongly suggestive of the rhynchonellid genus *Leiorhynchus*. *P. liorhyncha* differs from both of these species by its smaller size and lesser number of costae.

Holotype.—U. S. N. M. 95171a; unfigured paratypes, U. S. N. M. 95171b–e.

PENTAMERELLA LIORHYNCHA LIORHYNCHOIDEA Cooper and Cloud, n. var.
Plate 54, figures 12–16

Small, gibbous, subpentagonal in outline, lenticular in end profiles, longer than wide with the greatest width anterior to the midlength. Anterior margin uniplicate. Dimensions: length of ventral valve, 13.5 mm; length of dorsal valve, 11.5 mm; width, 12.5 mm; thickness, 9.3 mm.

Ventral valve strongly convex, curvature strongest at the umbo. Sulcus shallow, originating near the middle of the valve and marked by three costae; flanks marked by two to four costae. Beak strongly incurved, smooth.

Dorsal valve moderately convex, curvature strongest at the umbo. Three ribs mark each flank and four costae define the prominent fold. The dorsal costae are stronger than the ones on the ventral valve.

Remarks.—This variety differs from *Pentamerella liorhyncha* by having four costae on the fold, a more robust form, and more elongate ventral beak. It is represented by the holotype only.

Holotype.—U. S. N. M. 95173.

CRANAENA SUBCYLINDRICA Cooper and Cloud, n. sp.
Plate 54, figures 48, 49

Shell large for the genus, elongate, ovate in outline and lateral profile, two-thirds as long as wide, with the greatest width anterior to the midlength, anterior and posterior profiles subcircular, anterior margin gently uniplicate. Punctae elongate, medium coarse, 200 to 210 per square millimeter on the anterolateral edge of the dorsal valve. Dimensions: length of ventral valve, 21.5 mm; length of dorsal valve, 18.5 mm; width, 14.5 mm; thickness 13.0 mm.

The anterior half of the ventral valve is gently convex but the posterior half strongly convex in the umbonal region; umbo swollen; beak suberect; foramen large, labiate. Beak ridges moderately prominent. Uniplicate anterior margin produced by a flattening of the front quarter of the valve with the consequent production of a short tongue.

Dorsal valve evenly and moderately strongly convex, with a slightly convex umbo, a full mid- and anterior region; beak incurved, elongate.

Interior: Dental plates slightly convergent dorsally, extending about one-fifth the length. Pedicle collar present. Loop tenuous.

Remarks.—This species approaches *Cranaena iowensis* (Calvin) in size but differs by its more elongate and subcylindrical form.

Holotype.—U. S. N. M. 95174.

CRANAENA ROMINGERI (Hall)
Plate 54, figures 9–11, 17–18

Shell small, narrowly subovate in outline, longer than wide with the greatest width at midlength, elliptical in profile; anterior and posterior profiles subcircular, valves nearly equally convex; anterior margin uniplicate. Punctae medium coarse and closely spaced, 260 to 280 per square millimeter in the center of the ventral valve. Dimensions: length of ventral valve, 8.9 mm; length of dorsal valve, 7.7 mm; width, 7.0 mm; thickness, 6.0 mm.

Ventral valve moderately and evenly convex, curvature strongest at extremities. Lateral margins gently curved, anterior margin indented at the middle by a narrow, shallow sulcus extending about half the length. Beak erect; beak ridges, moderate; curvature of the umbo subdued.

Dorsal valve moderately but unequally convex; greater convexity at anterior where the slope to the anterior margin is steep. Umbo full. Posterior quarter marked by a barely perceptible sulcus.

Interior: Dental plates converging dorsally, in length equal to about one-sixth the length of the valve. Loop extending not quite half the length.

Remarks.—Among the cranaenas collected is a group of about 18 small, uniplicate specimens having a maximum length of 8 to 9 mm. The proportions of the dorsal valve range from longer than wide to subcircular. These specimens are conspecific with *Cranaena romingeri* (Hall) from the Partridge Point shale of Thunder Bay, Michigan, and the Coralville at Mid River, Iowa.

Hypotypes.—U. S. N. M. 95176a, b.

CRANAENA TINCTARADIATA
Cooper and Cloud, n. sp.
Plate 54, figures 27, 28

Ovate in outline, lenticular in profile, valves subequally convex; lateral margins gently convex, anterior emarginate. Anterior commissure strongly uniplicate. Valves ornamented by four dark-red radii. Dimensions: length of ventral valve, 8.5 mm; length of dorsal valve, 7 mm; width, 7 mm; thickness, 4.5 mm.

Ventral valve gently convex, marked by a moderately deep median sulcus which originates a little posterior to the middle of the valve. Dorsal valve moderately convex with the greatest convexity a little anterior to the middle.

Remarks.—This species differs from *C. romingeri* by its less rotund form, stronger ventral sulcus with consequent emarginate anterior and the dark-red radial ornamentation.

Holotype.—U. S. N. M. 95177a; paratype, 95177b.

CRANAENA AMYGDALOIDEA Cooper and Cloud, n. sp.
Plate 54, figures 24–26

Shell small for the genus, somewhat amygdaloidal in outline, about two-thirds as wide as long and half as thick as long, unequally biconvex in lateral profile, the ventral valve having the greater convexity, narrowly lenticular in posterior profiles, widest and thickest at midlength, rectimarginate. Punctae round, coarse and widely spaced, 140 per square millimeter on the umbo of the ventral valve. Dimensions: length of ventral valve, 12.0 mm; length of dorsal valve, 11 mm; width, 8.5 mm; thickness, 6.7 mm.

Ventral valve moderately convex with greatest convexity in umbonal region. Beak ridges inconspicuous; beak suberect. Dorsal valve gently and evenly convex, curvature strongest at the extremities. Umbo slightly swollen, beak short.

Remarks.—The external form and the coarse punctation distinguish this species from all others of the genus now known. Because only two of these almond-shaped shells were collected, we did not prepare serial sections. However, generic characters were partly observed by holding the translucent holotype over a strong light.

Holotype.—U. S. N. M. 95178a; unfigured paratype, 95178b.

CRANAENA RADIATA Cooper and Cloud, n. sp.
Plate 54, figures 29, 30, 35, 36, 43, 44

Shell of about medium size for the genus, longer than wide with the greatest width anterior to the midlength, subovate in outline, narrowly elliptical in lateral profile, with anterior and posterior profiles lenticular; rectimarginate. Punctae small and closely spaced, about 270 per square millimeter on the umbo of the ventral valve. Dimensions of holotype: length of ventral valve, 17.7 mm; length of dorsal valve, 15.2 mm; width, 13.8 mm; thickness, 9 mm.

Ventral valve moderately convex with the greatest convexity posterior to the middle. Posterolateral margins abruptly inflected towards the cardinal extremities, beak ridges angular. Umbo prominent, beak erect, foramen permesothyrid, deltidial plates conjunct.

Dorsal valve nearly circular in outline, somewhat less convex than the ventral valve with the greatest convexity posterior to the midlength and near the center.

Interior: Dental plates converging dorsally, extending about one-sixth the length of the shell. Loop long, extending about half the length of the shell.

Remarks.—Besides its external form, this species is characterized by six narrow maroon-colored radial bands, which extend from the umbo to the anterior and anterolateral margins. Many specimens having the same external form as the colored ones are assigned to this species, but most of them show no trace of color-banding. This species most nearly resembles a similarly color-marked *Cranaena* from the Lindwurm member of the Milwaukee formation in Milwaukee, Wisconsin. The Wisconsin specimens were described by Cleland as *Cranaena iowensis* (Calvin), but they differ from the Calhoun County species in having a more attenuate and erect ventral beak and more rounded and broader anterior.

Holotype.—U. S. N. M. 95179a; paratypes 95179d, e; unfigured paratypes 95179b, c.

CRANAENA MYRIOPUNCTATA Cooper and Cloud, n. sp.
Plate 54, figures 19–21

Shell small, extremely convex, longer than wide with the greatest width slightly anterior to the midlength, ventral valve having the greatest depth and convexity. Anterior margin faintly uniplicate. Punctae minute and closely spaced, approximately 425 per square millimeter on the ventral umbo. Dimensions: length of ventral valve, 12.3 mm; length of dorsal valve, 10.4 mm; width, 9.6 mm; thickness, 9.0 mm.

Ventral valve strongly convex with the curvature greatest a little posterior to the middle. Foramen labiate, permesothyrid. Beak suberect, ridges subdued.

Dorsal valve a little less convex than the ventral valve, curvature nearly even but greatest a little posterior to the middle.

Remarks.—Although this species is represented by the holotype only, it differs strongly from the other Calhoun County specimens. It is closest to *C. romingeri* (Hall) but differs in possessing a greater proportional length, less strongly folded anterior commissure and more numerous punctae per unit. Although the count of the punctae is not exact, the number obtained indicates that this species is more finely punctate than any other known from this horizon.

Holotype.—U. S. N. M. 95180.

CRANAENA sp.
Plate 54, figures 37, 45, 50, 51

A seventh species of *Cranaena* is represented by a large crushed example and several youthful specimens. The species approaches *C. iowensis* (Calvin) in size but differs by its stouter beak and more circular form. Figured specimens, U. S. N. M. 95175a, b.

ATRYPA sp.
Plate 54, figure 38

A small costellate *Atrypa* with narrow frill is one of the rarer fossils. Figured specimen, U. S. N. M. 95184.

MERISTELLA PARVA
Cooper and Cloud, n. sp.
Plate 54, figures 40, 46, 47

Shell very small for the genus, elongate-ovate in outline with the greatest width slightly anterior to the midlength, sublenticular in lateral profile; anterior and posterior profiles narrowly elliptical; anterior margin uniplicate. Dimensions: length of ventral valve, 10.4 mm; length of dorsal valve, 9.5 mm; width, 7.3 mm; thickness, 5.2 mm.

Ventral valve moderately and evenly convex. A broad shallow sulcus extends about half its length and forms a short tongue. Beak ridges prominent, curvature of umbo subdued. Beak suberect.

Dorsal valve less convex than the ventral, fullest in the umbonal region. Anterior half of valve flattened. Anterior margin broadly arched to form a barely perceptible fold.

Interior: Dental plates short, extending about one-sixth the length of the ventral valve, sub-parallel posteriorly but diverging in a lateral direction at about their midlength. Cruralium of the dorsal valve large, septum short.

Remarks.—Thirteen entire specimens and seven isolated valves represent this small species, which is distinguished from other known members of the genus by its elongate and slender form and the brevity of the median septum supporting the cruralium.

Holotype.—U. S. N. M. 95181a; figured paratype 95181b; unfigured paratypes 95181c–g.

"SPIRIFER" sp. 1
Plate 54, figures 4–8

Three specimens of a small species of spiriferoid belonging to a tribe having an imbricate exterior and a more or less well developed median septum in the ventral valve, were found. These may represent the young of a large form, but if so, no adults were collected. The species represented belongs to the same group of spiriferoids as "*Sp.*" *pauliformis* J. S. Williams. Figured specimen U. S. N. M. 95182a.

"SPIRIFER" sp. 2
Plate 54, figures 1–3

This small species differs from the preceding by its larger size, more elevated beak, shorter inter-area, narrower hinge, less angular cardinal extremities and stronger imbrications on the exterior. It also may be the young of a larger species. Figured specimen U. S. N. M. 95183a.

ELYTHA aff. E. FIMBRIATA
(Conrad)
Plate 54, figure 42

Four poorly preserved specimens are referred tentatively to the group of spiriferoids typified by *E. fimbriata* (Conrad). Figured specimen, U. S. N. M. 95187.

PELECYPODA

Besides the substantial number of brachiopods, the *Scutellum* fauna contains at least ten genera of pelecypods. A number of these are represented by specimens too poor in preservation or too few in number to be accurately identified or described as new species. The genera *Modiomorpha* (of the type of *M. mytiloides* Conrad), *Mytilarca*, and *Phthonia* (of the type of *P. cylindrica*) are represented each by one specimen only. *Lyriopecten* is represented by one specimen of a strongly wrinkled species besides the one described below as new. A single right valve of a *Palaeoneilo* is related to *P. constricta* (Conrad). *Cypricardinia*, very close to *C. indenta* (Conrad), is represented by 15 specimens mostly immature. A left valve of an elongate type of *Nuculites* is well within the range of variation of *N. oblongatus* (Conrad). Pending needed revision of this species the Calhoun County form has been placed here. A single left valve of a small species of *Conocardium* is probably new but not good enough for description.

PHTHONIA sp.
Plate 54, figure 41

A single specimen of a narrowly elongated clam is referred to this genus. Figured specimen U. S. N. M. 95188.

PALAEONEILO n. sp.
cf. P. CONSTRICTA (Conrad)
Plate 55, figure 2

Only one specimen of this genus was collected. Figured specimen U. S. N. M. 95190.

NUCULITES sp.
cf. N. OBLONGATUS (Conrad)
Plate 55, figure 3

One specimen is referred here doubtfully. Figured specimen U. S. N. M. 95193.

NUCULITES NASUTUS
Cooper and Cloud, n. sp.
Plate 55, figure 1

This species is represented by one right valve and one left valve, the holotype. *Nuculites nasutus* differs from its nearest relative, *N. oblongatus* (Conrad), by its elongate and nasute anterior end. The holotype measures 23 mm in length and about 13 mm in height.

Holotype.—U. S. N. M. 95194a; unfigured paratype 95194b.

LEPTODESMA MINUTUM
Cooper and Cloud, n. sp.
Plate 55, figures 4–6

At first sight this species suggests the smaller leptodesmas of the Hamilton group, which have usually been referred to *Leptodesma rogersi* Hall. This species differs from *L. rogersi* by its uniformly smaller size, more convex valves and more elevated beaks. The holotype is 7 mm long and 6 mm in height.

Holotype.—U. S. N. M. 95191a; paratype 95191b.

CONOCARDIUM BELLUM
Cooper and Cloud, n. sp.
Plate 55, figures 7, 8, 10–12

This beautiful species is represented by four well-preserved specimens. *Conocardium bellum* is of about medium size for the genus, subtrigonal in outline, longer then wide with body of valves full and swollen, fullest at the posterior but thinning gradually to form the anterior slope. Anterior elongate, nasute, obliquely truncated at the front. Anterior gaping narrowly, anteroventral portion of valves denticulate. Posterior margin obliquely truncated; posterior slope of body short, descending to a shallow narrow furrow, which separates the body of the shell from a narrow flange or extension. Beaks posterior. Posterior slopes concave meeting in the middle to form a sharp ridge that rises to the beaks to form short ears.

Body of shell marked by low, flattened radii separated by shallow striae wider than the radii. Anteriorly the radii become wider to the line where the anterior slope of the body of the shell passes into the nasute anterior. Here the radii abruptly become angular. The entire surface is covered by fine concentric lines of growth. The posterior slope is marked by growth lines only.

Remarks.—This species is unlike any other described Devonian *Conocardium* in the brevity of the posterior marginal flange, the subdued character of the ornamentation and in having the posterior slope marked by growth lines only.

Holotype.—U. S. N. M. 95192a; paratypes 95192c, d; unfigured paratype 95192b.

ACTINOPTERA BREVIALATA
Cooper and Cloud, n. sp.
Plate 54, figures 61, 62

The holotype preserves a complete left valve and about one half of the right valve. Both wings are well preserved, but the right ear is lost. The specimen is of about medium size for the genus, strongly oblique.

Left valve: Umbonal region narrow, swollen, beak low but incurved over the hinge. Anterior slope steep, posterior slope gentler and separated from the ear by a sharply defined groove. Anterior margin narrowly rounded, ventral margin broadly rounded. Ear small, swollen; sulcus shallow. Wing small, triangular, posterior margin concave, extremity pointed. Body and wing of shell covered by elevated radial lines about eight in five millimeters at the anterior margin.

One finer radial line may occur between the strong lines. These radial lines are crossed by strong concentric lines about eight or nine in five millimeters. The left valve of the holotype is 27 mm long and 35 mm high.

Beak and umbonal region of right valve not so prominent as those of the left. Wing gently concave, radially ornamented. Body of valve with closely spaced concentric ornamentation only.

Remarks.—Of described species of *Actinoptera* the Calhoun County form most closely resembles *A. boydi* (Conrad) of the lower Hamilton. It differs, however, by its less prominent beak, more oblique form, and much smaller wing, which is separated from the body of the valves more sharply.

Holotype.—U. S. N. M. 95189a; paratype 95189b; unfigured paratype 95189c.

LYRIOPECTEN ILLINOISENSIS
Cooper and Cloud, n. sp.
Plate 54, figures 53, 54, 57

Shell of about medium size, slightly oblique, a little longer than high, widest a little below the middle. Hinge line a little shorter than the greatest width. Valves subequal in convexity, the left valve having a little greater convexity.

Left valve swollen in the umbonal and midregions, beak a little elevated over the hinge. Anterior umbonal slope steep. posterior slope gentle. Ears subequal, the posterior ear a little the larger and more pointed. Right valve less convex than the left one, with gently swollen mid- and umbonal regions; beak low, not overhanging the hinge, posterior slope steep and abrupt. Posterior ear large, broadly triangular; anterior ear smaller, narrowly triangular and acutely pointed.

Surface of left valve marked by radii of unequal size, a fine radius between two stronger ones. Four to six of the larger radii occupy a space of 5 mm at the base of a valve 25 mm high. The radii are crossed by strong distant concentric elevated lines about 5 in 5 mm at the base of a valve 25 mm high. Ornamentation of left valve similar but a little finer.

Measurements: Young left valve (U. S. N. M. 95196b), 16 mm long, 14 mm high; large right valve (U. S. N. M. 95196a), 24 mm long, 23 mm high.

Remarks.—This species is close to *Aviculopecten exactus* Hall, but differs in the possession of a shorter hinge line, greater convexity, and stronger ornamentation.

Figured syntypes.—U. S. N. M. 95196a–c; unfigured syntypes 95196d–m.

CYPRICARDINIA sp.
cf. C. INDENTA (Conrad)
Plate 54, figures 55, 56, 60

The fact that all of the good specimens of this genus found are of young individuals prevented a more accurate determination of the species. Figured specimens, U. S. N. M. 95195a, b.

GASTROPODA
PLATYCERAS sp.
Plate 55, figures 16, 17

The only representative of this class is a small species represented by two specimens. Figured specimen, U. S. N. M. 95197a.

CEPHALOPODA

A single specimen of a large gomphoceroid probably belonging to the genus *Acleistoceras*, is the only member of this phylum known from these beds.

TRILOBITA
DECHENELLA ELEVATA
Cooper and Cloud, n. sp.
Plate 55, figures 20–22, 24–27

Cephalon: Subsemicircular in outline, moderately convex, length equal to two-thirds the greatest width. Glabella a little swollen, frontal lobe curving evenly and strongly towards preglabellar field, lateral slopes gentle. The glabellar furrows are represented by three pairs of smooth inconspicuous transverse impressions. The first pair arises just anterior to the eyes and is very short, bifurcating medially with one branch directed obliquely forward and one obliquely backward. The second pair is about half again as long as the first pair and originates just posterior

to the anterior end of the eyes and is curved gently backward. The third pair is the longest, bifurcating at about mid-length and with one branch transverse and the other directed posteriorly at a sharp angle. Occipital lobes prominent, subtrapezoidal, pustulose medially. Fixed cheek almost obsolete, palpebral lobe elongate subcrescentic. Occipital ring moderately broad medially, narrowing laterally, flattened, arched medially and marked centrally by a prominent tubercle. Occipital furrow narrow, deep centrally but shallow at the lobes. Preglabellar furrow deep. Preglabellar field narrow, gently convex posteriorly, concave anteriorly with front border upturned. Anterior border narrow, slightly elevated, concave, separated from preglabellar field by a sharp raised line.

Free cheeks subtrapezoidal, longer than wide, gently concave laterally but swollen medially, suborbital grooves broadly rounded. Genal angles extended into sharp spines which would reach to about the fourth or fifth thoracic segment. Postmarginal furrows deep, becoming shallow as they extend anteriorly on the genal spines. Lateral border slightly elevated, concave, separated from the cheek proper by a sharp line. Eyes subreniform, elongate, swollen, holochroal, situated about one-third the length of the cephalon from the posterior margin.

The entire surface of the head is finely pitted, the pits becoming coarser medially and posteriorly, but so minute on the preglabellar field and lateral extremities of the free cheeks as to be only barely visible. Superimposed on this fine ornamentation is a coarser pattern of irregularly scattered pustules. The largest of these occupy the posterior part of the glabella, the occipital ring, and the highest parts of the occipital lobes. Laterally and anteriorly the pustules abruptly become finer and more scattered. They are completely missing on the preglabellar field, the depressed lateral part of the free cheeks, and all furrows and depressions. On the raised part and slopes of the free cheeks the fine scattered pustules are interrupted by small shallow depressions, which may be subcircular or transversely elongate. The anterior border is separated from the preglabellar field by a single sharp slightly raised line. In the lateral borders this line either continues or is replaced by a series of broken lines, which may be continuous, overlapping, or parallel. On the genal spine these lines become more numerous.

Thorax: Only a few segments of the thorax are present. These are ornamented by large pustules on the axial ring, and bear medially a prominent tubercule or short blunt spine. Axial furrows prominent but not deep.

Pygidium: Outline subtrapezoidal, length equal to about two-thirds the width, strongly convex both axially and transversely. Axial lobe strongly elevated above the depressed pleural lobes, its width at anterior margin a little more than one-third that of the pygidium and extending about seven-eighths the length of the latter, gently tapering posteriorly to an abruptly rounded extremity. Axial lobe with ten axial rings and a short terminal piece separated on the anterior side by a deep furrow, but by a shallow furrow on the posterior side. The first six rings bear prominent median nodes, which decrease in size posteriorly. Pleural lobes five, with an incipient sixth, which is obscure in adults. The four anterior pairs of pleura consist of anterior and posterior pleural bands of subequal convexity and extend from the axial furrow to the inner margin of the lateral border; the posterior pairs are obscure. The doublure is moderately wide and occupies one-sixth of the half width of the pygidium. The entire surface is finely punctate and, as on the cephalon and thoracic segments, a coarser pattern of pustules is present. These are concentrated on the high parts of the axial and pleural lobes, the posterior pleural bands carrying the most and the largest. The broad lateral border is the most densely pustulate part of the entire test.

Hypostoma: Outline subrectangular,

twice as long as wide, convexity very strong laterally but gentle longitudinally, curvature gentle on top but abruptly curving to straight vertical sides. Widest at the short anterior margin, anterolateral extremities extended into articulating flanges. Posterior border wide, gently convex in middle, ornamented with transverse subparallel lines. Posterolateral furrow conspicuous. Two prominent lateral indentations mark the posterior end of the central part. Surface ornamented by elevated anastomosing lines

Measurements: Cephalon (syntype, U. S. N. M. 95200b), 30.5 mm wide, 19.0 mm long, 8 (?) mm high. Pygidium (syntype, U. S. N. M. 95200 d) 23.4 mm wide, 16.6 mm long, 8.5 mm high.

Remarks.—The description of this species is based on four heads with their counterparts, five pygidia and one hypostome. *Dechenella elevata* resembles *D. prouti* (Sherwood) from the Cedar Valley formation of Iowa, discussed by Walter (7), but differs in the possession of a much shorter and blunter genal spine, that of *D. prouti* reaching to the eighth or ninth thoracic segment. *Dechenella rowi* (Hall) differs from *D. elevata* in having a narrower preglabellar field, a less convex pygidium, more swollen free cheeks and in the possession of only three median axial nodes on the pygidium instead of six.

Figured syntypes.—U. S. N. M. 95200a, d, g, j; unfigured syntypes, 95200b, c, e, f, h, i.

CORNUPROETUS CALHOUNENSIS
Cooper and Cloud, n. sp.
Plate 55, figures 9, 13–15, 18, 19, 23

Cephalon: Longitudinally subquadrate in outline, strongly convex in lateral profile with the front convex and steep; frontal lobe of glabella swollen and rounded, descending steeply to the preglabellar furrow. Glabellar furrows faint, directed in a posteromedian direction, increasing in length posteriorly. Fourth glabellar furrow bifurcating posteriorly to define an obscure narrow lobe. Occipital lobe small. Occipital furrow narrow, deep; occipital ring large, swollen to the level of the posterior half of the glabella. A small tubercle occupies the center of the occipital ring about one-third its length from the posterior margin. Fixed cheeks almost obsolete, palpebral lobes small. Preglabellar field very narrow; anterior border narrow, marked by elevated concentric lines.

Free cheeks: Small, subtrapezoidal in outline; genal extremity narrowly rounded; body of cheek gently swollen; marginal furrow deep, lateral border narrow. Eye holochroal.

Thorax: Unknown.

Pygidium: Longitudinally semielliptical in outline, a little wider than long; gently convex in lateral profile, more strongly convex in posterior profile. Axis elevated, swollen, tapering gradually to a narrow extremity. Axial rings about sixteen, the last two indistinct. Pleural lobes swollen; pleura about eight in number, the last one very indistinct. Lateral furrow shallow, lateral border broad, convex.

Ornamentation: The front and middle parts of the glabella are marked by short wavy ridges, which decrease in length towards the posterior. In the posterior third of the cephalon the wavy ridges pass into tiny pustules. Besides the ridges the entire glabella is minutely punctate. The occipital lobes are smooth.

The entire surface of the pygidium except the furrows between the pleura, the axial rings and the axial furrows, is ornamented by irregularly shaped, low pustules. The furrows are smooth.

Measurements: Cephalon (syntype U. S. N. M. 95199a) 11 mm long, 10 mm wide measured across the palpebral lobes. Pygidium (syntype U. S. N. M. 95199c, f) 18 mm long, 22 mm wide; 10 mm long, 12 mm wide.

Remarks.—This species is represented by 8 pygidia and 6 cephala of varying sizes. None of the cephala represents a full-grown animal although the specimens are clearly adults. A fragmentary tail and head indicate that the species at-

tained a large size. The largest tail is incomplete but measures 23 mm in length.

The younger specimens of this species suggest *Proetus searighti* and *P. bumastoides* Walter. From the former the Calhoun County species differs in having less strongly impressed furrows between the axial rings and pleura and in possessing a strongly pustulose ornamentation. The cephalon of *P. searighti* is more evenly rounded and ornamented by much stronger tubercles and wavy ridges.

Proetus bumastoides differs from *Cornuproetus calhounensis* in possessing more elongate, stronger and more closely

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EXPLANATION OF PLATE 54

FIGS. *1–3*—"*Spirifer*" sp. 2. Dorsal, side and ventral views of a nearly perfect specimen, ×2. Figured specimen (95183a). (p. 451)

4–8—"*Spirifer*" sp. 1. *4*, Dorsal view, ×1; *5–8*, side, ventral, posterior and dorsal views of the same specimen, ×2. Figured specimen (95182a). (p. 451)

9–11, 17, 18—*Cranaena romingeri* (Hall). *9–11*, Side, anterior and dorsal views of an exceptionally ventricose specimen, ×1, hypotype (95176a); *17, 18*, dorsal and side views of a less ventricose specimen, hypotype (95176b). ×1. (p. 449)

12–16—*Pentamerella liorhyncha liorhynchoidea* Cooper and Cloud, n. var. Side, ventral posterior, anterior and dorsal views of the holotype (95173), ×1. (p. 448)

19–21—*Cranaena myriopunctata* Cooper and Cloud, n. sp. Dorsal, ventral and side views of the holotype (95180), ×1. (p. 450)

22, 23—*Productella navicella* Hall. Ventral and side views of a hypotype (95186a), ×1. (p. 447)

24–26—*Cranaena amygdaloidea* Cooper and Cloud, n. sp. Dorsal, side and anterior views of the holotype (95178a), ×1. (p. 449)

27, 28—*Cranaena tinctaradiata* Cooper and Cloud, n. sp. Respectively, dorsal views of a color-marked but imperfect paratype (95177b) and the nearly perfectly preserved holotype (95177a), ×1. (p. 449)

29, 30, 35, 36, 43, 44—*Cranaena radiata* Cooper and Cloud, n. sp. *29, 44*, Side and dorsal views of the holotype (95179a) coated by ammonium chloride to show lateral margin, foramen and deltidial region, ×1; *35, 43*, respectively, ventral and dorsal views of the uncoated holotype showing traces of color bands; *30, 36*, uncoated specimens showing color marks, paratypes (95179d, 95179e), ×1. (p. 450)

31–34—*Pentamerella liorhyncha* Cooper and Cloud, n. sp. Ventral, dorsal, side and anterior views of the holotype (95171a), ×1. (p. 447)

37, 45, 50, 51—*Cranaena* sp. *50, 51*, Dorsal and ventral views of a large but crushed example, figured specimen (95175a), ×1; *37, 45*, side and dorsal views of a young example, figured specimen (95175b, ×1. (p. 450)

38—*Atrypa* sp. Ventral view of a specimen (95184) showing the small body and wide frills, ×1. (p. 450)

39—*Pholiodstrophia* sp. A ventricose ventral valve (95185), ×1. (p. 447)

40, 46, 47—*Meristella parva* Cooper and Cloud, n. sp. *40*, Dorsal view of the holotype (95181a), ×1; *47*, the same, ×2; *46*, cross-section near the beak of a paratype (95181b) showing the dorsal cruralium, ×6. (p. 451)

41—*Phthonia* sp. Small left valve, figured specimen (95188), ×1. (p. 451)

42—*Elytha* aff. *E. fimbriata* (Conrad). A small ventral valve, figured specimen (95187), ×1. (p. 451)

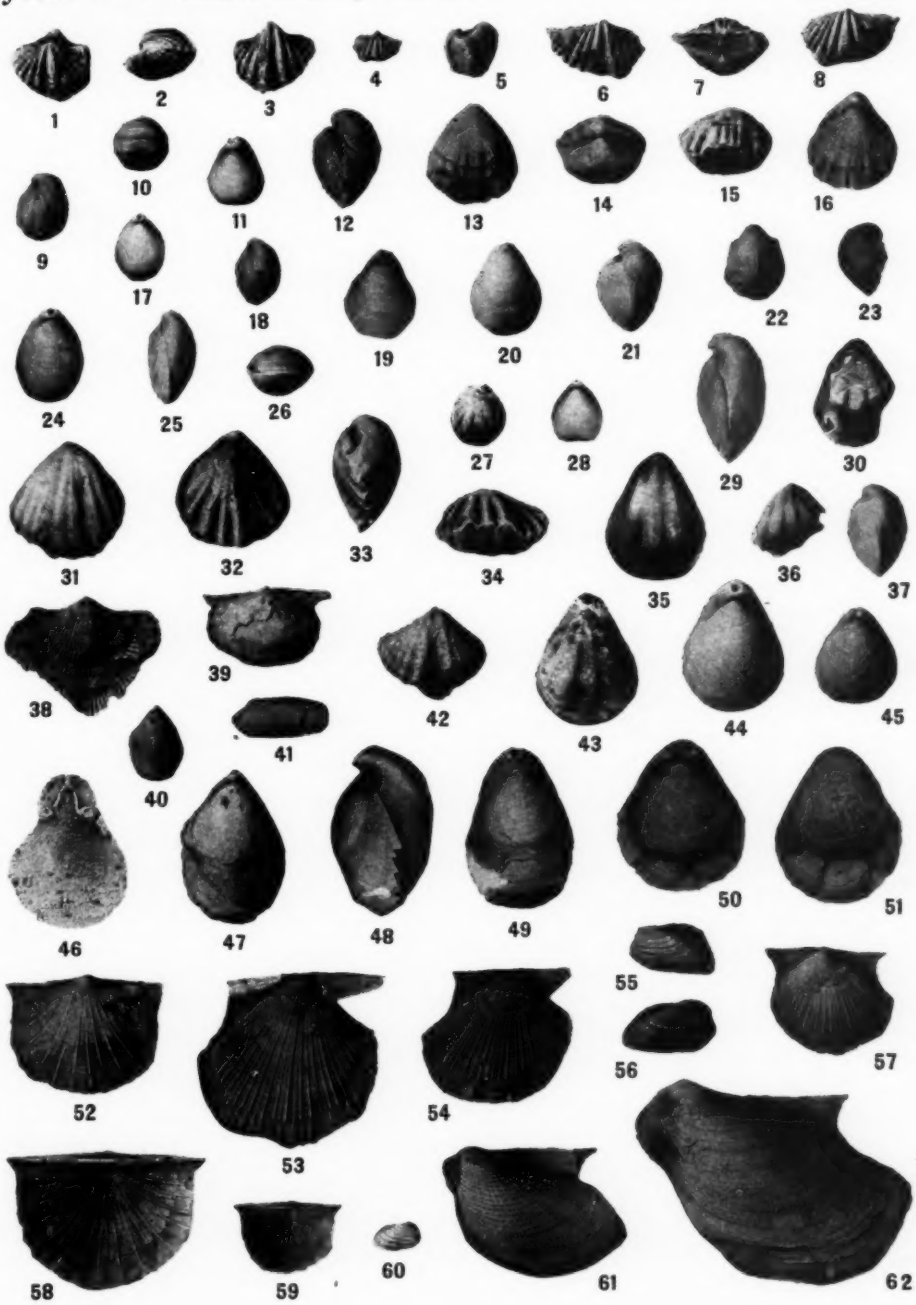
48, 49—*Cranaena subcylindrica* Cooper and Cloud, n. sp. Side and dorsal views of the holotype (95174), ×1. (p. 448)

52, 58, 59—*Douvillina bellistriata* Cooper and Cloud, n. sp. *52*, Ventral valve, syntype (95170b), ×2; *58*, dorsal valve, syntype (95170a), ×2; *59*, the latter natural size. (p. 446)

53, 54, 57—*Lyriopecten illinoisensis* Cooper and Cloud, n. sp. *53*, Impression of the interior of a right valve, ×1, syntype (95196a); *54*, exterior of a right valve, ×1, syntype (95196c); *57*, plasticine replica of a left valve, ×1, prepared from syntype (95196b). (p. 453)

55, 56, 60—*Cypricardinia* cf. *C. indenta* (Conrad). *55, 56*, Respectively, left and right valves, ×2, figured specimens (95195b, 95195a); *60*, the same right valve, ×1. (p. 453)

61, 62—*Actinoptera brevialata* Cooper and Cloud, n. sp. Respectively, large and small left valves, ×1, paratype (95190b), and holotype (95190a). (p. 452)



Cooper and Cloud, Devonian Fossils

Cooper and Cloud, Devonian Fossils

crowded ridges on the head. The cephalon of *P. bumastoides* is also a little wider proportionately than that of the Illinois species.

Holotype.—U. S. N. M. 95199a; paratypes 95199c, e, f, g; unfigured paratypes 95199b, d.

CORDANIA PULCHRA
Cooper and Cloud, n. sp.
Plate 55, figures 28, 29, 31–34

Cephalon: Outline semicircular, evenly rounded in front with the length slightly more than half the width, lateral extremities produced into long spines. Glabella elongate, widest near the middle, narrowly rounded at the front. Frontal lobe somewhat swollen, but sloping towards the preglabellar field. First glabellar furrow reduced to an oblique depression deepening anterolaterally and uniting with a shallow depressed area on each side of the frontal lobe. Second glabellar lobe narrow and a little swollen. Second glabellar furrow, deep. Occipital lobes trapezoidal, slightly swollen, and bearing a prominent tubercle at their highest point. Fixed cheek broad, palpebral lobe

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EXPLANATION OF PLATE 55

FIGS. *1*—*Nuculites nasutus* Cooper and Cloud, n. sp. Left valve, ×1, the holotype (95194a). (p. 452)

2—*Palaeoneilo* n. sp. cf. *P. constricta* (Conrad). Right valve, ×1, figured specimen (95190). (p. 452)

3—*Nuculites* cf. *N. oblongatus* (Conrad). Left valve, ×1, figured specimen (95193). (p. 452)

4–6—*Leptodesma minutum* Cooper and Cloud, n. sp. *5*, Wax replica prepared from a mold of a small left valve, ×1, holotype (95191a); *4*, the same, ×2; *6*, a large left valve showing decreasing obliquity with size, ×2, paratype (95191b). (p. 452)

7, 8, 10–12—*Conocardium bellum* Cooper and Cloud, n. sp. *7, 8, 10*, Respectively, views of the right valve, ventral margin and anterior of the holotype (95192a), ×1; *11*, right valve of a paratype (95192c) ×1, showing slightly produced posterior; *12*, posterior view of a small paratype (95192d), ×2. (p. 452)

9, 13–15, 18, 19, 23—*Cornuproetus calhounensis* Cooper and Cloud, n. sp. *14*, A cranidium, the holotype (95199a), ×1, *13*, another cranidium, paratype (95199e), ×2; *15*, the left free cheek, ×2, paratype (95199g); *18, 19*, dorsal and side views of a large pygidium, ×1, paratype (95199c); *23*, another smaller pygidium, ×1, paratype (95199f). (p. 455)

16, 17—*Platyceras* sp. Side views of the larger specimen, figured specimen (95197). (p. 453)

20–22, 24–27—*Dechenella elevata* Cooper and Cloud, n. sp. *20, 21*, Dorsal and side views of an imperfect cranidium, ×1, syntype (95200j); *22*, another more complete cranidium, ×1, syntype (95200a); *24*, dorsal view of a nearly perfect pygidium, ×1, syntype (95200g); *25–27*, respectively, posterior, side and dorsal views of a larger pygidium, ×1, syntype (95200d). (p. 453)

28, 29, 31–34—*Cordania pulchra* Cooper and Cloud, n. sp. *28*, A nearly perfect cranidium, ×1, holotype (95198a); *34*, the same, ×3; *31*, another cranidium without the free cheeks, ×2, paratype (95198c); *29*, posterior view of a pygidium ×2, paratype (95198d); *32, 33*, dorsal and side views of another pygidium, ×2, paratype (95198e). The left free cheek was inadvertently removed from *28*. (p. 457)

30, 35, 38—*Scutellum tullium* (Hall). *30*, Dorsal view of a cranidium, ×1, hypotype (95202a); *38*, a free cheek, ×2, hypotype (95202b); *35*, anterior view of a small head, ×2, showing convexity, hypotype (89742). Compare with *39*. (p. 459)

36, 39–45—*Scutellum tullium depressum* Cooper and Cloud, n. var. *41*, Wax replica of the dorsal surface prepared from the mold (holotype 95201a) of a nearly complete cranidium, ×1; *42, 43*, a large and small cranidium, ×1, ×3, paratypes (95201b, 95201g); *44*, another small cranidium, ×1, paratype (95201e); *39*, anterior view of the same, ×2, to be compared with *35*. The anterior brim is upturned and therefore not visible in this view. *40, 45*, A small and large pygidium, ×1, paratypes (95201h, 95201c); *36*, side view of the latter, ×1. (p. 458)

37—*Scutellum tullium depressum* Cooper and Cloud, n. var. Dorsal view of an imperfect cranidium, ×1, figured specimen (95203). Upper part of the Petoskey formation, 1.1 miles north of Norwood, Charlevoix County, Michigan. (p. 459)

narrowly rounded. Occipital furrow wide and deep, neck ring broad. Preglabellar furrow shallow, preglabellar field broad and wide, concave, with the front border upturned.

The entire surface of the head is pitted. The pits of the glabellar and fixed cheeks are very fine and in the nature of punctae, but the pits on the preglabellar field and the free cheeks are large. Small and large tubercles are present on portions of the head. They are scattered over the surface of the glabella but are concentrated on the preglabellar field in a narrow area just anterior to the preglabellar furrow. A large tubercle is also located on the fixed cheek opposite the center of the eye.

Free cheeks forming a narrow inequilateral triangle, widest near the eyes and drawn to a point at the apex. The marginal furrow is deep and wide and extends to the extremity of the genal spine. The postmarginal furrow is short but deep and runs into the lateral marginal furrow. The lateral and posterior margins are sharply upturned. The eye is small, holochroal, and located about two-thirds the length of the head from the anterior margin.

Thorax: Unknown.

Pygidium: Outline crudely pentangular, a little wider than long, gently convex and with truncate posterior in lateral profile. Strongly lobate in posterior profile with the axial lobe strongly elevated above the depressed and flattened pleural lobes. Axial lobe narrowly elevated, with ten pleura. Each pleuron bears a central large tubercle or blunt spine flanked on each side by two smaller tubercles. One or two additional columns of small tubercles, depending on the size of the tail, may be present on the nearly vertical lateral slopes of each axial ring. Pleural lobes eight in number. Each pleuron consists of a strongly elevated anterior pleural band extending from the axial furrow to the margin and a low rounded obscure posterior pleural band behind the preceding. This band may nearly reach the margin of the most anterior two or three pleura but posterior to these are confined to the flattened portion of the pleural lobe near the axial furrow. Marginal furrow deep, margin of tail flexed a little horizontally. Prominent pleural ribs marked by strong tubercles, which, however, do not extend to the margin but leave the marginal portion of the pleura smooth. Entire surface finely punctate.

Measurements: Cephalon (holotype) 11 mm wide, 6 mm long, height 3 mm ? Pygidium (paratype, U. S. N. M. 95198b) 9.5 mm wide, 7 mm long, 3 mm in height.

Remarks.—The genus *Cordania* was proposed in 1892 by John M. Clarke (8) for a group of species that had been indifferently assigned to *Cyphaspis* and *Phaetonides*. The earliest members of the group in America appear in the Helderberg of New York, and the stock lived at least through Tully time. One species, *C. raripustulosa* (Walter), is known from the upper Cedar Valley limestone at Mid River, Iowa. The Illinois species differs from *C. raripustulosa* (Walter) by its more tuberculate and more strongly punctate head, narrower frontal glabellar lobe and more strongly impressed glabellar furrows.

Holotype.—U. S. N. M. 95198a; paratypes, 95198c, d, e; unfigured paratype, 95198b.

Scutellum tullium depressum
Cooper and Cloud, n. var.
Plate 55, figures 36, 39–45

Cephalon: Approximately semicircular in outline, depressed in profiles, glabella subpyriform in outline. In lateral and anterior profile the central part of the glabella is moderately swollen. Frontal lobe of glabella extending almost to front margin, depressed convex, slightly rounded at the front. First glabellar furrows shallow, narrow, directed slightly anteromedianly and ending in a deep pit in the palpebral furrow. Second glabellar furfows nearly horizontal, short, shallow, obscure, isolated from the palpebral furrow. The third and fourth glabellar furrows are united in a median direction

to form a shallow C-shaped depression surrounding a small tuberculate area, the remnantal fourth glabellar lobe. This C-shaped depression and the lobe it surrounds are located on a line just anterior to the front end of the eyes. Occipital lobes depressed, not well defined. Occipital ring broad with a strong median tubercle.

Fixed cheek elongate, widest near the eyes, tapering to the anterior margin to merge with a very narrow preglabellar field. This field is almost obsolete at the front of the head. Palpebral lobe narrowly extended laterally.

Free cheek broadly triangular, genal angle blunt but acute, eye small, reniform, schizochroal, Marginal furrow broad and shallow, lateral margin upturned with the degree of flexure increasing from the nearly flat genal angle to the place of union with the fixed cheek near the frontal lobe of the glabella.

The entire surface of the head is strongly tuberculate with the size of the tubercles diminishing toward the margins. The anterior portion of the glabella and the fixed cheeks are also marked by fine elevated anastomosing lines in the spaces between the tubercles.

Thorax: The complete thorax is unknown but one specimen preserves a few very narrow tuberculate segments.

Pygidium: Semi-elliptical in outline, a little longer than wide. The anterior three-fifths are flat in lateral and posterior profiles but are elevated above the posterior two-fifths. The slope from the elevated anterior portion to the depressed marginal region is strong. Anterolateral extremities narrowly rounded; lateral margins converging slightly to a broadly rounded posterior margin. Axis short, broadly triangular, equal in length to about one-fifth the length of the tail; seven pleura occur on each side of the central pleuron. Entire surface of tail tuberculate.

Measurements: Cephalon (holotype) length 16 mm, width 30 mm. Pygidium (paratype U. S. N. M. 95201c), length 26 mm, width 33 mm.

Remarks.—The description of this species is based on about 30 specimens but only a few pieces represent remains of old adult animals. These specimens indicate that the head attained a width of at least 40 mm and the tail a length of at least 39 mm.

This Illinois example of *Scutellum* is so close to *S. tullium* (see plate 55, figures 30, 35, 38), that we have assigned it to varietal rank. The major difference in the cephalon is the more depressed character of the head of the Illinois form. This depressed convex head is shown by all of the specimens in the collection, young and old alike. The tails of New York and Illinois specimens are much more alike than the heads and differ in very minor characters only. The axis of the New York species is a little more swollen than that of the Illinois form and the swollen platform of the tail is a little longer in the New York species and with a distinctly gentler posterior slope.

Holotype.—U. S. N. M. 95201a; paratypes, 95201b, c, e, g, h; unfigured paratypes, 95201d, f, i, j.

Scutellum tullium depressum
Cooper and Cloud (from Michigan)
Plate 55, figure 37

One fragmentary cephalon was taken from beds equivalent to the Partridge Point formation, 1.1 miles north of Norwood on the shore of Lake Michigan. The glabella has the same depressed form and proportions as the Illinois examples.

Figured specimen: U. S. N. M. 95203.

Scutellum tullium (Hall)
Plate 55, figures 30, 35, 38

A pygidium in the Museum of Comparative Zoology at Harvard shows tiny spines along the margin. These were observed also by J. M. Clarke but overlooked by Cooper and Williams in a discussion of this species. Clarke assigned the Tully species to the genus *Thysanopeltis* on the basis of these spines. This assignment, however, is not correct because not only are the spines of *Thysanopeltis* larger and less numerous, but the

whole structure of the tail is different from that of *Scutellum*. A free cheek of the New York form is figured here for the first time.

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MIDDLE AND UPPER CAMBRIAN FAUNAS FROM WESTERN NEWFOUNDLAND

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ABSTRACT

A late Middle Cambrian fauna with *Marjumia* and *Eldoradia* and the early Upper Cambrian *Cedaria* and *Crepicephalus* zones occur in western Newfoundland. The March Point formation is restricted to the Middle Cambrian and the name Petit Jardin formation is proposed for Upper Cambrian beds at Cape St. George. Two new genera and fourteen new species are described.

In their memoir on the stratigraphy of western Newfoundland, Schuchert and Dunbar recognized and described Upper Cambrian terranes at several scattered localities (1a). A restudy of the fossil collections has revealed that all the faunas represented belong to the American province and can be correlated directly with standard North American faunal zones. Moreover, the lower part of the March Point formation as originally described was found to be late Middle Cambrian in age, and the upper part carries only the earliest Upper Cambrian fauna.

The author takes this opportunity to express her deep appreciation of Dr. Percy E. Raymond's kindness and generosity in making available to her Dr. Schuchert's 1918 collections and the Harvard Museum collection from the Cow Head breccia. She also wishes to thank Dr. C O. Dunbar for the loan of the 1933 collections from the Peabody Museum at Yale, and Dr. C. E. Resser of the United States National Museum for the loan of material from Schuchert's 1910 collection.

THE CAMBRIAN SECTION ON CAPE ST. GEORGE

Cambrian strata are continuously exposed on both flanks of a large anticline for seven miles along the southern shore of Cape St. George. An interrupted section of 1187 feet was measured on the eastern flank from March Point to Big Cove, described as the March Point formation, and assigned to the Upper Cambrian (fig. 1). Fossils were obtained from

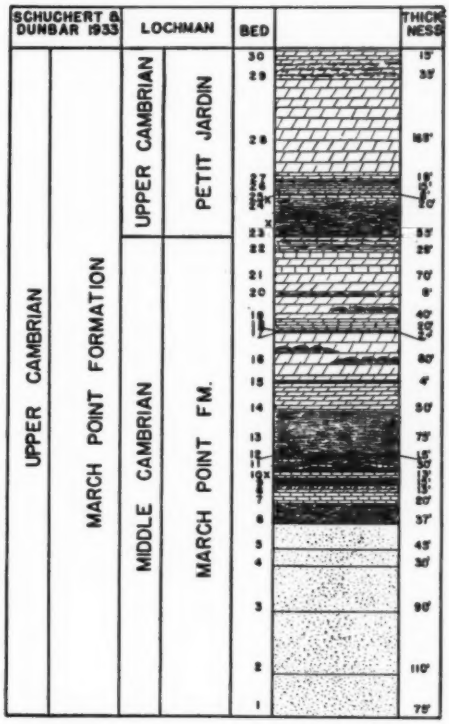

FIG. 1.—Section between March Point and Big Cove.

three horizons, beds 10, 23 and 24. The identification of this material places the fauna of bed 10 in the Middle Cambrian

and that of beds 23 and 24 in the *Cedaria* zone of the Upper Cambrian.

The lowest collection, from bed 10, consists of slabs of fine-grained dark-gray knobbly limestone. Though the fossils are numerous, the fauna is distinctly poor in species, containing only two species of trilobites, *Marjumia newfoundlandensis* Lochman, n. sp., and *Eldoradia dunbari* Lochman, n. sp., and an undetermined species of the brachiopod *Obolus*.

The species of *Eldoradia* seems, from the number of individuals in the material, to have dominated the faunal assemblage, but this feature may be a reflection of preservation, for specimens of the larger *Marjumia* could be obtained only from the weathered surfaces. *Marjumia* has been described previously only from the Marjum formation in the House Range, Utah, and *Eldoradia* only from the Eureka district, Nevada. According to present Middle Cambrian correlation a zone characterized by *Neolenus* and *Marjumia* is recognized near the top of the Middle Cambrian section of the Cordilleran region (2), and although the fauna of this zone is not well known, all available evidence suggests a limited stratigraphic range for the genus *Marjumia*. Therefore, the Middle Cambrian fauna of bed 10 is tentatively considered the direct zonal equivalent of the *Neolenus-Marjumia* fauna of the Rocky Mountains.

The higher collections, from beds 23 and 24, contain a fauna representative of the *Cedaria* zone. The material from bed 23 is gray-green micaceous shale with rounded phosphate pellets. It carries only flattened and slightly distorted cranidia and pygidia of *Arapahoia raymondi* Lochman, n. sp., and crushed valves of *Lingulella* cf. *quadrilateralis* Walcott. The collection from bed 24 occurs in a dark-gray crystalline limestone near the top of the bed and contains a larger and better preserved fauna as follows:

FAUNA OF BED 24

Arapahoia raymondi Lochman, n. sp.
Millardia avitas Walcott
Welleraspis newfoundlandensis Lochman, n. sp.
Coosella helena Lochman, n. sp.
Maryvillia arion Walcott
Talbotina degrasensis Lochman, n. gen., n. sp.
Talbotina solitaris Lochman, n. sp.
Dicellomus nanus (Meek and Hayden)

A third collection, obtained from dark-gray crystalline limestones outcropping in the vicinity of Little Green Gardens, represents the horizon of beds 23 and 24 on the west flank of the anticline, and was found to carry a small fauna of the same age including *Arapahoia raymondi* Lochman, n. sp., *Kingstonia ara* (Walcott), *Talbotina* sp. undet., and *Lingulella* sp. undet.

The most pertinent fact brought out by this study is the close faunal relationship that appears to have existed between the western Newfoundland region and the Rocky Mountain area during the late Middle and earliest Upper Cambrian time. The known geographic range of *Marjumia*, *Eldoradia*, and *Arapahoia* is restricted to these regions. This faunal similarity, supplemented by Poulsen's recognition of the close relations between the Greenland and Rocky Mountain Middle Cambrian faunas, suggests a direct connection of both the Newfoundland and the Cordilleran areas with the arctic seas; and the periodic migrations southeastward and southwestward into these regions of boreal genera, which tended to dominate the resultant faunal assemblages.

The fauna of bed 24 has also furnished important information concerning the Cambrian connections between the Newfoundland and the Appalachian regions. The recognition of the genus *Welleraspis* associated with a fauna of *Cedaria* age affords the first direct evidence available for a definite zonal correlation of faunas from the Kittatinny limestone of New Jersey. It is considered highly probable that *Welleraspis* had a restricted stratigraphic as well as geographic range and that, consequently, the lower third of the Kittatinny limestone (which contains the

beds carrying *Welleraspis*) is the time equivalent of at least the lower half of the Dresbach formation of Wisconsin. The occurrence in the same fauna from Newfoundland of *Millardia avitas* Walcott and *Kingstonia ara* Walcott, both species described from the Warrior limestone of Pennsylvania, furnishes additional evidence of a connecting seaway between the two regions in early Upper Cambrian time.

Since the March Point formation as originally described is now known to contain beds of both Middle and Upper Cambrian age, which are probably separated by a hiatus, the author proposes to restrict the March Point formation to the Middle Cambrian part of the section, the lower 850 feet (beds 1–22 inclusive). The Middle-Upper Cambrian boundary is placed at present arbitrarily between beds 22 and 23. The fauna of beds 23 and 24, characterized by *Arapahoia*, belongs to the lower part of the *Cedaria* zone, the oldest faunal zone assigned to the Upper Cambrian.[1] Therefore, although they contain only Cryptozoons of unknown age, it is considered probable that beds 11–22 are latest Middle Cambrian in age. Beds 1–10 are of proven Middle Cambrian age on the basis of the fauna of bed 10 and their stratigraphic position.

The name Petit Jardin formation is proposed for the upper 337 feet of the section (beds 23–30 inclusive). Beds 23 and 24 are of proven early Upper Cambrian age, and the author considers it quite probable that beds 25–27 are also of this age. However, until fossils have been obtained from these higher beds their exact correlation will remain in doubt. The type locality of the formation is in the measured section of Schuchert and Dunbar in Big Cove east of March Point, on the east flank of the anticline. The name is adopted from Petit Jardin (Little Green Gardens) near which strata of this formation are exposed on the west flank of the anticline.

[1] In the Cordilleran region the *Marjumia—Neolenus* zone, with which the fauna of bed 10 is correlated, is separated from the *Cedaria* fauna by a younger Middle Cambrian faunal zone.

UPPER CAMBRIAN BLOCKS IN THE COW HEAD BRECCIA

Four small collections from three different localities on Cow Head Peninsula were prepared slab by slab to eliminate the possibility of mixture of fossil zones during collecting. Two collections made by Dr. Dunbar from a single horizon (about one foot thick) in one of the Cambrian blocks near Cow Head village were used as a control. A single faunal assemblage was found to occur in all the collections, and it can be stated with reasonable certainty that all the blocks represented by these collections were derived from the same Upper Cambrian sequence. The fauna, referred to the base of the *Crepicephalus* zone, contains the following species:

UPPER CAMBRIAN FAUNA IN THE COW HEAD BRECCIA

Crepicephalus sp. undet.
Meteoraspis borealis Lochman, n. sp.
Norwoodia katherina Lochman, n. sp.
Kingstonia vagrans Lochman, n. sp.
Coosella intermediens Lochman, n. sp.
Dendrograptus kindlei Reudemann
Blountia cf. *B. mimula* Walcott
Acrotreta schucherti Lochman, n. sp.
Linguella holyokensis Lochman, n. sp.
Agnostus gen. and sp. undet.
Coosella cf. *C. helena* Lochman, n. sp.
Tricrepicephalus sp.

The faunal assemblage, with *Meteoraspis* and *Norwoodia* as the dominant genera, would, were it not for the presence of *Crepicephalus*, represent a group typical of the uppermost *Cedaria* zone in the Texas and Montana sections. Although *Meteoraspis* was not previously known to extend into the *Crepicephalus* zone, the present knowledge of faunas of this age is not complete enough to validate a positive statement as to its exact stratigraphic range. Specimens of *Norwoodia* do occur rarely in the basal *Crepicephalus* beds of Wisconsin. Furthermore, a careful search of all the material has not revealed even a fragment of an *Arapahoia*. *Cedaria* and *Arapahoia*, the key genera of

the *Cedaria* zone, dwindled rapidly in numbers and importance in the latter half of *Cedaria* time and, though still present, constituted a very minor element of the fauna, which might be easily overlooked. Therefore, because of the absence of *Arapahoia*, and the definite presence of a species of *Crepicephalus*, the fauna is placed in the basal *Crepicephalus* zone and is believed to represent a provincial assemblage of species, relic of the *Cedaria* zone, which has been invaded by *Crepicephalus*. The strata of these blocks in the Cow Head breccia are to be correlated with the middle Eau Claire member of the Dresbach formation of Wisconsin.

The species in Schuchert's 1910 collection from the Cow Head breccia, now in the United States National Museum, identified by E. O. Ulrich and listed by Schuchert and Dunbar (1b) have been reidentified as follows:

Ulrich's Identification	Author's Identification
Linguella cf. *L. lepis* (Salter)	*Lingulella holyokensis* Lochman, n. sp.
Crepicephalus like *C. comus*	*Meteoraspis borealis* Lochman, n. sp.
Agraulos sp.	*Blountia* cf. *B. mimula* Walcott
Norwoodia, 2 new species	*Norwoodia katherina* Lochman, n. sp. *Terranovella obscura* Lochman, n. gen. and n. sp.

The correlation suggested by Dr. Ulrich was essentially correct in view of the limited knowledge at that date of the Upper Cambrian. The Maryville limestone of Tennessee, which he mentions, has subsequently been shown to be limestone beds in the Nolichucky shale, which contains both the *Cedaria* and the *Crepicephalus* zones as well as the higher *Aphelaspis* zone. The upper part of the Conasauga shale of Alabama also carries these zones, and the Missouri horizon that Dr. Ulrich had in mind is the basal part of the Bonneterre dolomite, which carries a typical late Cedaria fauna.

UPPER CAMBRIAN IN BAY OF ISLANDS REGION

Schuchert and Dunbar (1c) record a collection of Upper Cambrian trilobites from shales underlying the St. George series in the section exposed in the north wall of Humber Gorge. The material consists of five distorted and quite undeterminable fragments of trilobite thoraces on the badly squeezed shale partings of gray fine-grained marble. The condition of the specimens makes any accurate dating of these beds impossible.

SYSTEMATIC DESCRIPTIONS

MARJUMIA NEWFOUNDLANDENSIS Lochman, n. sp.

Plate 56, figures 32–35

Cranidium large, having a moderately convex conical glabella with a broad median ridge; three pairs of short, broad glabellar furrows, posterior pair arcuate; occipital furrow shallow and narrow; occipital ring wide, slightly convex; dorsal furrow narrow and shallow. Fixed cheeks one-half width of glabella, convex; palpebral lobes medium-sized, semicircular, situated on the transverse median line of glabella; palpebral furrow narrow; ocular ridge wide, prominent, extending diagonally to dorsal furrow behind front of glabella; frontal limb narrow, slightly convex transverse furrow well-defined; frontal border wider than frontal limb, convex; anterior margin rounded. Posterolateral limbs long and narrow with a broad shallow intramarginal furrow. Free cheeks wide, subtriangular, eye at inner angle of wide ocular platform, marginal border and doublure wide, with short very slender genal spines. Facial suture cutting anterior margin well out from center, curving outward and then backward to palpebral lobes, around which it passes, then continuing outward and backward to cut posterior margin within genal angle.

Hypostoma oval in outline; anterior margin unknown; anterior lobe elevated, oval; posterior lobe semicircular, convex; posterior and lateral margins narrow, rimlike; two pairs of maculae present.

Pygidium transverse and heavy; axial lobe of medium width, strongly convex, extending full length of pygidium, and marked by six broad segments and sharply tapered terminal portion; pleural lobes wider than axial, marked by four wide segments, which terminate at margin in short spines, graduated in size; pleural furrows broad and shallow.

Outer surface of test covered thickly with medium-sized granules. Inner surface finely punctate. The radiating venations on frontal limb and ocular platforms very thick and prominent, distinguishable on outer as well as inner surface of test.

This species represents the second well-defined form assignable to *Marjumia*. The distribution of the genus as now known would suggest that it was definitely boreal in origin. Unfortunately none of the specimens is really perfectly preserved, all having weathered out on the surface of limestone slabs.

Occurrence.—Middle Cambrian, March Point formation (horizon 38Z10), near southern tip of March Point about one-fourth mile from Jim Young's wharf, southern shore of Cape St. George.

Types.—Holotype, a cranidium, Y.P.M.[2] 15801; paratype, free cheek, Y.P.M. 15801; paratype, hypostoma, Y.P.M. 15802; paratype, pygidium, Y.P.M. 15801.

ELDORADIA DUNBARI
Lochman, n. sp.
Plate 56, figures 36–43

Cranidium short and broad with a slightly convex narrow conical glabella; three pairs of short shallow arcuate glabellar furrows; occipital furrow broad and shallow on median line, narrow and deep at sides; occipital ring narrow and flat with a small median node; dorsal furrow narrow and deep along sides, shallow along front of glabella. Fixed cheeks three-fourths width of glabella, slightly convex, strongly elevated along the ocular ridge; palpebral lobes of medium size, wide and crescentiform, situated slightly posterior to transverse median line of cranidium; palpebral furrows broad and shallow; ocular ridge wide, arcuate; frontal limb moderately wide with a low transverse median boss; transverse furrow narrow with two points of widening at sides of boss; frontal border narrow, flat; anterior margin rounded. Posterolateral limbs short and wide with a deep broad intramarginal furrow. Free cheek narrow, with elevated ocular platform, narrow flat marginal border, and short slender genal spine. Facial suture cutting anterior margin on line with dorsal furrow, curving backward to transverse furrow and thence straight back to palpebral lobe, around which it passes and continues outward and backward in a curve to cut posterior margin well within genal angle.

Pygidium semicircular with pleura curved sharply backward to the nearly straight posterior margin; axial lobe narrow, strongly convex, extending nearly full length of pygidium, marked by six narrow V-shaped segments and a terminal section; pleural lobes same width as axial, low, sloping down to narrow flat marginal border; five wide pleural segments fading out onto border.

Outer surface of test finely granulated; inner surface coarsely punctate with well-developed venations on the frontal limb and ocular platform.

The large number of specimens of this species in the collection has made possible a very complete description of the form. From the numbers present, the species would appear to have been the dominant form of this faunal assemblage, although this feature may be caused by the better preservation of this smaller-sized species. The holotype represents the normal adult size, and no cranidia have been obtained longer than 17 mm.

The species is distinctive in the poor

[2] Peabody Museum, Yale University.

development of the frontal median boss, a character also found in *E. prospectensis* (Walcott).

Occurrence.–Middle Cambrian, March Point formation (horizon 38Z10), near southern tip of March Point about one-fourth mile from Jim Young's wharf, southern shore of Cape St. George.

Types.—Holotype, cranidium, Y.P.M. 15804; paratype, cranidium, Y.P.M. 15807; paratype, free cheek, Y.P.M. 15805; paratype, pygidium, Y.P.M. 15806.

ARAPAHOIA RAYMONDI
Lochman, n. sp.
Plate 57, figures 17–25

Cranidium oblong with a low conical glabella; two pairs of short faint glabellar furrows and a narrow median glabellar ridge distinguishable on the inner surface; occipital furrow narrow and shallow; occipital ring flat, subtriangular with a short heavy spine; dorsal furrow narrow and shallow, outlining glabella on inner surface. Fixed cheeks flat, narrow, one-fourth width of glabella; palpebral lobes small and narrow, crescentiform, situated on transverse median line of cranidium; frontal limb and border of same width, slightly convex, separated by a narrow shallow transverse furrow, anterior margin broadly rounded. Posterolateral limbs broad and short with a broad intramarginal furrow. Free cheek nearly flat, subtriangular, with eye at inner angle; marginal furrow very shallow; genal spine long, very slender. Facial suture cutting anterior margin on line with dorsal furrow, curving outward and then running straight back to palpebral lobes, around which it passes, and thence curving outward and backward abruptly to cut posterior margin well within genal angle.

Pygidium transverse, axial lobe of medium width, strongly convex, extending nearly full length of pygidium, with outer surface marked by two segments, inner surface by three segments; pleural lobes slightly narrower than axial, flat, sloping down into the narrow convex marginal border; four broad pleural segments delimited by narrow furrows; shallow pleural furrows distinguishable on anterior pairs.

Outer surface of test smooth, with sparsely scattered punctations; inner surface densely punctate, posterior margin of pygidium marked by narrow irregular ridges; frontal limb and ocular platform with faint traces of coarse venation.

This species is the dominant form of the early *Cedaria* fauna not only in the Rocky Mountain area but also in the southwestern Newfoundland region. In the two localities from Newfoundland from which this material was collected the great abundance of individuals affords an excellent series of growth stages from cranidia 1.5 mm in length to those of senile individuals over 20 mm in length. The type cranidium and pygidium represent a young adult. It is interesting that this species is most similar to *Arapahoia butleri* (Stoyanow) from the Abrigo limestone of Arizona.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone), outcrop on south shore of Cape St. George, near Little Green Gardens.

Types.—Holotype, cranidium, Y.P.M. 15863; paratypes, cranidia, Y.P.M. 15865, Y.P.M. 15869; paratype, free cheek, Y.P.M. 15868; paratypes, pygidia, Y.P.M. 15867, 15864, 15866.

KINGSTONIA ARA (Walcott)
Plate 57, figures 5–8

Ucebia ara WALCOTT, *1924*, Smithsonian Misc. Coll., vol. 75, no. 2, p. 60, pl. 14, fig. 4. WALCOTT, *1925*, Smithsonian Misc. Coll., vol. 75, no. 3, p. 118, pl. 17, figs. 7, 8.
Kingstonia ara (Walcott) RESSER, *1936*, Smithsonian Misc. Coll., vol. 95, no. 4, p. 24.

Supplementary description: Pygidium triangular in outline, nearly flat; axial lobe of medium width, flat, faintly marked by nine narrow segments, and a low narrow median ridge; dorsal furrow along sides of axial lobe only; pleural lobes same width as axial, flat, marked by six broad segments; marginal border

narrow, convex, sloping down abruptly to margin.

Outer surface unknown; inner surface of test coarsely punctate.

This species is represented by only six specimens, none perfect. Its occurrence is most interesting in that it affords a direct correlation with the Warrior limestone of Pennsylvania.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone), outcrop on south shore of Cape St. George, near Little Green Gardens.

Types.—Figured cranidium, Y.P.M. 15860; plesiotype, pygidium, Y.P.M. 15861.

Genus TALBOTINA
Lochman, n. gen.

Cranidium convex, subquadrate with a broadly conical glabella; two pairs of weak glabellar furrows; dorsal furrow narrow, well defined, occipital ring convex, of medium width; fixed cheeks about one-third width of glabella; palpebral lobes of medium size, situated on transverse median line of glabella, shallow palpebral furrow; frontal limb and border convex, separated by a narrow, well-defined transverse furrow; posterolateral limbs of medium length and width with a narrow intramarginal furrow. Free cheek unknown.

Pygidium small, slightly transverse with a strongly convex axial lobe extending nearly full length, marked by three segments and a broad terminal portion; pleural lobes narrower than axial, nearly flat, with three broad segments crossed by faint pleural furrows; marginal border narrow, flat.

Outer surface of test granulated.

This genus contains a number of small trilobites, which appears as a persistent but never very common member of the *Cedaria* fauna both in Newfoundland and the Rocky Mountain region. It appears to be most closely related to *Weeksina* of the Weeks formation, House Range, Utah.

The name is given in honor of Miss Mignon Talbot.

Genotype.—*Talbotina degrasensis* Lochman, n. gen., n. sp.

TALBOTINA DEGRASENSIS
Lochman, n. sp.
Plate 56, figures 12–15

Cranidium subquadrate in outline with a long conical glabella; two pairs of glabellar furrows, posterior pair well defined, strongly arcuate, anterior pair shorter, slightly curved; occipital furrow deeply impressed at sides, shallow on median line; occipital ring of moderate width and convexity with a small median node; dorsal furrow narrow, deeply impressed along sides of glabella. Fixed cheek narrow, one-third width of glabella, convex; palpebral lobe of medium size, flat, crescentiform, situated on the transverse median line of glabella; ocular ridge narrow, well defined; frontal limb of medium width, convex; transverse furrow narrow, V- shaped; frontal border narrower than limb, convex. Posterolateral limbs narrow, moderately long, marked by a deep, intramarginal furrow. Free cheek narrow, with eye at inner angle of low ocular platform; marginal border of medium width, slightly convex, with a short slender genal spine. Facial suture cutting anterior margin near sides, curving outward and thence running straight back to palpebral lobes, around which it passes, and then curving outward and backward to cut posterior margin well within genal angle.

Pygidium transverse with strongly convex axial lobe extending nearly full length of pygidium, divided into three segments and a broad terminal part by narrow shallow furrows; pleural lobes same width as axial, slightly convex, sloping gently into the narrow flat marginal border; pleural lobes divided by deep narrow furrows into three broad segments marked by long shallow pleural furrows.

Outer surface of test covered with small granules; inner surface coarsely punctate; frontal border and marginal border marked by several narrow imbricating ridges.

Cranidium, 5½ by 5½ mm; pygidium, 4½ by 2½ mm.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24), outcrop on east flank of anticline on south shore of Cape St. George.

Types.—Holotype, cranidium, Y.P.M. 15829; paratype, cranidium, Y.P.M. 15830, paratype, free cheek, Y.P.M. 15827; paratype, pygidium, Y.P.M. 15828.

TALBOTINA SOLITARIS
Lochman, n. sp.
Plate 56, figures 16–18

Cranidium subquadrate in outline with an elongate, convex, conical glabella; two pairs of shallow arcuate glabellar furrows; occipital furrow narrow, well defined; occipital ring of moderate width and convexity with a small median node; dorsal furrow narrow, deep along sides and shallow across front of glabella. Fixed cheeks one-third width of glabella, slightly convex; palpebral lobe of medium size, flat, crescentiform, situated on the transverse median line of glabella; ocular ridge narrow, faint; frontal limb narrow, flat, sharply downturned; transverse furrow narrow, shallow, very slightly V-shaped; frontal border narrow, flat. Free cheek not known. Pygidium not known.

Outer surface of test covered with small granules.

This species is founded on a single cranidium of *Talbotina*, which differs markedly in the proportions of the frontal limb and border from the commoner cranidia of *Talbotina degrasensis* Lochman, n. sp.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24) outcrop on east flank of anticline on south shore of Cape St. George.

Type.—Holotype, cranidium, Y.P.M. 15826.

COOSELLA HELENA
Lochman, n. sp.
Plate 57, figures 9–15

Cranidium short and broad with a broadly conical, convex glabella; three pairs of short shallow glabellar furrows; occipital furrow broad and shallow; occipital ring of medium width, flat; dorsal furrow deep and narrow, outlining glabella. Fixed cheeks one-third width of glabella, slightly convex; palpebral lobes medium sized, situated on transverse median line of glabella; palpebral furrows shallow; ocular ridge narrow, low, meeting dorsal furrow posterior to front of glabella; frontal limb narrow, slightly convex; transverse furrow broad, well-defined; frontal border narrow, convex. Posterolateral limbs of medium length, narrow, marked by a broad, deep intramarginal furrow.

Pygidium semicircular, wider than long; axial lobe of moderate width and convexity, extending two-thirds length of pygidium, marked by four segments and a tapered terminal portion; pleural lobes slightly wider than axial, flat on top and then sloping abruptly down to the broad, flat marginal border; four pleural segments delimited by broad, shallow furrows and marked by narrow pleural furrows; posterior margin incurved at median axial line, giving a bilobed appearance to border.

Outer surface of test covered with fine granules, and frontal border marked by three narrow transverse ridges; inner surface coarsely punctate.

This species is the most common form of the *Cedaria* faunal assemblage at this upper horizon. The pygidia are numerous and well preserved and indicate a wide range in individual size. The cranidia are somewhat rarer, and only the smaller sizes appear to have been capable of good preservation.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24), outcrop on east flank of anticline on south shore of Cape St. George.

Types.—Holotype, cranidium, Y.P.M. 15814; paratype, cranidia, Y.P.M. 15815, 15819; paratypes, pygidia, Y.P.M. 15816, 15817, 15818.

COOSIA sp. undet.
Plate 57, figures 39, 40

A number of pygidia belonging to the genus *Coosia* occur in the collection, but

as no cranidia of the genus have been obtained and the pygidia do not closely resemble any of the described species of *Coosia*, it is considered advisable to leave the form undescribed for the present but to figure it so that it may be available to others for reference.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24), outcrop on east flank of anticline on south shore of Cape St. George.

Figured specimen.—A pygidium, Y.P.M. 15825.

MARYVILLIA ARION Walcott
Plate 57, figure 4

Maryvillia arion WALCOTT, *1916*, Smithsonian Misc. Coll., vol. 64, no. 5, p. 400, pl. 64, figs. 4, 4a–c.

A number of pygidia that appear to be identical with those assigned to *Maryvillia arion* Walcott from the Nolichucky formation of Tennessee occur in the collections. They are tentatively referred to the species until cranidia of the genus have been obtained, as it is impossible to determine from the pygidia alone whether this form represents the same species or a closely related one.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24), outcrop on east flank of anticline on south shore of Cape St. George.

Figured specimen.—Y.P.M. 15821.

MILLARDIA AVITAS Walcott
Plate 56, figures 27, 28

Millardia avitas WALCOTT, *1916*, Smithsonian Misc. Coll., vol. 64, no. 3, p. 165.

A number of fragmentary specimens referable to *Millardia* occur in the collection, but only the specimen figured, which consists of the glabella as well as posterolateral limb and free cheek, warrants an attempt at specific identification. This specimen is, in all observable details, identical with *M. avitas* Walcott from the Warrior limestone of Pennsylvania.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24), outcrop on east flank of anticline on south shore of Cape St. George.

Figured specimen.—Cranidium, Y.P.M. 15822.

WELLERASPIS NEWFOUNDLANDENSIS Lochman, n. sp.
Plate 56, figures 9–11

Cranidium short and broad with a large subquadrate tumid glabella; two pairs of prominent glabellar furrows, posterior pair arcuate, anterior pair short and straight; occipital furrow broad, deeply impressed at sides and shallow on median line; occipital ring triangular, flat, extending backward into a short, broad spine; dorsal furrow narrow, outlining glabella. Fixed cheeks narrow, less than one-third width of glabella, flat near glabella and then sloping abruptly down to small palpebral lobe; frontal limb narrow, slightly convex; transverse furrow narrow, shallow; frontal border narrow, upturned. Posterolateral limb short and broad, marked by a deep, broad intramarginal furrow.

Free cheek and pygidium not known.

Outer surface of test very finely granulated.

Only one incomplete specimen of a cranidium has been obtained, but because of its distinctive features and the fact that its identification as a species of *Welleraspis* affords the first direct evidence of the presence of the *Cedaria* fauna in New Jersey, it has been considered desirable to describe the new species.

The occurrence of this species further substantiates the evidence afforded by *Kingstonia ara* (Walcott) of a direct connection between the southwestern Newfoundland region and the central Appalachian area, at least during the earliest Upper Cambrian time. It is now possible to correlate the lower third of the Kittatinny limestone with the other formations of known early Dresbach age.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24), outcrop on east flank of anticline on south shore of Cape St. George.

Type.—Holotype, cranidium, Y.P.M. 15823.

DICELLOMUS NANUS (Meek and Hayden)
Plate 57, figures 1–3

Obolella nana MEEK and HAYDEN, *1862*, Acad. Nat. Sci. Philadelphia, Proc. for 1861, vol. 13, pp. 435–436.
Dicellomus nanus (Meek and Hayden). WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51, p. 573. (Gives complete synonymy.)

A small number of dorsal valves referable to this species occur in the collection. They show the strong convexity of the valves particularly characteristic of the species.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z24), outcrop on east flank of anticline along south shore of Cape St. George.

Figured specimens.—Y.P.M. 15810, 15811.

LINGULELLA sp. cf. L. QUADRILATERALIS (Walcott)
Plate 57, figure 26

Obolus (*Lingulella*) *quadrilateralis* WALCOTT, *1905*, U. S. Nat. Mus. Proc., vol. 28, p. 331.
Lingulella quadrilateralis (Walcott). WALCOTT, *1912*, U. S. Geol. Survey, Mon. 51. p. 528, pl. 39, figs. 6, 6a.

A number of *Lingulella* valves occur flattened in the shale beds that carry the *Cedaria* fauna in the Upper Cambrian section on the east flank of the anticline along the south shore of Cape St. George. It is associated with a great abundance of specimens of *Araphoia raymondi* Lochman, n. sp., and the two forms constitute the entire faunal assemblage of the horizon at this locality.

All the specimens are flattened and a large number are badly distorted. The species has been referred doubtfully to *L. quadrilateralis* (Walcott) as many of the valves possess the quadrate shape that Walcott considered the diagnostic feature, but it is quite probable that this outline may have been produced by the flattening in the shale.

Occurrence.—Upper Cambrian, Petit Jardin formation (*Cedaria* zone, horizon 38Z23), outcrop on east flank of anticline along south shore of Cape St. George.

Figured specimens—Y.P.M. 15858.

BLOUNTIA sp. cf. B. MIMULA Walcott
Plate 56, figures 25, 26

Blountia mimula WALCOTT, *1916*, Smithsonian Misc. Coll., vol. 64, no. 5, p. 399.

One small cranidium and several pygidia, none perfectly preserved, occur in collections from this horizon at two localities. In respect to their size and to all structural details of the cranidium and pygidium that can be determined, they appear to be identical with *B. mimula* Walcott from the Nolichucky shale of Tennessee.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone).

Figured specimens.—Cranidium, Y.P.M. 15847, loc. 2, north end of Cow Head Peninsula, just west of Cow Head village. Pygidia, Y.P.M. 15876; outer side of Cow Head Peninsula facing Stearing Island.

COOSELLA INTERMEDIENS Lochman, n. sp.
Plate 57, figures 30–33

Cranidium short with a broadly conical, slightly convex glabella; no trace of glabellar furrows; occipital furrow moderately wide, shallow; occipital ring of medium width, nearly flat; dorsal furrow narrow, well defined. Fixed cheeks narrow, one-fourth width of glabella; palpebral lobes medium-sized, situated on transverse median line of glabella; palpebral furrow narrow and shallow; frontal limb flat, same width as convex frontal border; transverse furrow narrow and shallow. Posterolateral limbs of medium length, narrow, marked by a narrow, well-defined intramarginal furrow.

Pygidium broadly transverse with a narrow strongly convex axial lobe extending slightly over two-thirds its length; axial lobe divided by faint furrows into three segments and a large tapered terminal portion; pleural lobes

wider than axial, sloping evenly down to the moderately wide, flat marginal border, which is slightly incurved at the posterior median point; pleural lobes marked by three broad faintly furrowed segments.

Outer surface smooth except for frontal border of cranidium, which is marked by several narrow parallel transverse ridges.

This species is quite interesting and important in that the structures of the cranidium and pygidium evince a combination of features of both *Coosia* and *Coosella*, a fact that has made the exact generic determination difficult. The types are small and not too well preserved, but the form seems closest to *Coosella*.

Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone), northeast side of Cow Head Peninsula.

Types.—Holotype, a cranidium, Harvard Museum 4484; paratype, a pygidium, Harvard Museum 4485, 4486.

CREPICEPHALUS sp. undet.
Plate 57, figure 16

Pygidium transverse; axial lobe of medium width, convex, extending over three-fourths length of pygidium, marked by three poorly defined segments and a terminal portion; pleural lobes same width as axial, slightly convex, divided into three broad segments; moderately wide, flat marginal border extended at posterolateral corners into a pair of short, slender spines.

The form cannot be described specifically because no cranidium can be assigned to the pygidia in the collection. The pygidia all occur on weathered surfaces and consequently are poorly preserved. In respect to the general outline, proportions, and the direction of the spines, the pygidium is not unlike that assigned to *C. iowensis*, but the marginal border is somewhat narrower and the spines much shorter.

The collection also contains one fragmentary specimen with a portion of the pygidium, 8 thoracic segments, and the genal spine of the free cheek.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone), outer side of Cow Head Peninsula, facing Stearing Island.

Figured pygidia.—Y.P.M. 15845.

KINGSTONIA VAGRANS
Lochman, n. sp.
Plate 56, figures 22–24

Cranidium small with a broadly conical, slightly convex glabella; glabellar furrows and occipital furrow obsolete on outer surface; dorsal furrow narrow, outlining glabella on inner surface of test. Fixed cheeks narrow, one-third width of glabella, flat; palpebral lobes minute; frontal limb narrow, sloping regularly from front of glabella to narrow transverse furrow; frontal border narrow, vertical. Posterolateral limbs short and broad, marked on inner surface by a broad, shallow intramarginal furrow. Facial suture cutting anterior margin on a line with dorsal furrow, curving smoothly outward and backward to palpebral lobe around which it passes, thence running outward and dropping abruptly backward to cut posterior margin at genal angle.

Pygidium subtriangular in outline; axial lobe of medium width, slightly convex; pleural lobes wider than axial, flat, turning down abruptly at the edges to the flat vertical marginal border, which gradually increases in width to the posterior median line; three segments distinguishable on inner surface.

Outer surface of test smooth.

This small species is one of the more common members of this faunal assemblage. It is apparently most closely related to *K. apion* Walcott of the Nolichucky limestone of Tennessee.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone), loc. 3, north end of Cow Head Peninsula, just west of Cow Head village.

Types.—Holotype, a cranidium, Y.P.M. 15841; paratype, a pygidium, Y.P.M. 15842; paratype, a cranidium and a pygidium, Y.P.M. 15842.

CREPICEPHALIDAE Kobayashi, 1935
METEORASPIS Resser, 1936

Supplementary description: Transverse furrow of the cranidium marked by two broad shallow pits, one on each side of the median line of the cranidium. Free cheek short and broad with a wide convex ocular platform, a narrow well-defined marginal furrow and a thick convex marginal border ending in a short, slender genal spine.

Thorax composed of 13 segments; axial lobe convex; pleural lobes wider than axial, flat for about one-half the length, then sloping downward to the falcate termination; pleural furrows broad and deep.

Pygidium short and heavy, square in outline, with a pair of short, slender posteriorly directed spines extending from the posterolateral corners of the marginal border of the pygidium.

The single cranidium of *Meteoraspis metra* (Walcott) upon which the genus was established was too poorly preserved to show the presence of the pits in the transverse furrow. Since then the many collections obtained from Texas and the Rocky Mountain region as well as from Newfoundland have furnished details of the entire carapace and enable a satisfactory classification of the genus. *Meteoraspis* is very closely related to *Tricrepicephalus*, and either evolved directly from *Tricrepicephalus* or from a common ancestral genus. It is much more sharply restricted in stratigraphic range, occuring only in the upper portion of the *Cedaria* zone and the very base of the *Crepicephalus* zone; whereas species of *Tricrepicephalus* occur throughout both zones. In respect to geographic range, *Meteoraspis* occurs in collections from Missouri, Texas, the Rocky Mountain area, and western Newfoundland.

METEORASPIS BOREALIS
Lochman, n. sp.
Plate 56, figures 1–5

Cranidium short with moderately convex, conical glabella; no trace of glabellar furrows; occipital furrow broad and deep; occipital ring of medium width, convex; dorsal furrow broad, well defined. Fixed cheeks narrow, one-fifth width of glabella, convex; palpebral lobes medium-sized, situated on transverse median line of glabella; palpebral furrow wide and shallow; narrow diagonal ocular ridge reaching dorsal furrow some distance behind front of glabella; frontal limb extremely narrow, sloping sharply down to the broad, deep transverse furrow marked by two elongate shallow pits; frontal border of medium width, strongly convex. Posterolateral limbs of medium width, short, marked by a broad, deep intramarginal furrow. Free cheek subtriangular; ocular platform broad, convex, with eye at inner angle; marginal border of medium width, convex, terminating in a short, slender genal spine. Facial suture cutting anterior margin near center of cranidium, curving outward to transverse furrow, then running straight back to palpebral lobe around which it curves, and thence passing outward and backward to cut posterior margin.

Thorax composed of thirteen segments; axial lobe convex; pleural lobes flattened for about one-half their length, then sloping backward to the short falcate terminations; pleural furrows broad and deep.

Pygidium short, square in outline with a broad convex axial lobe extending three-fourths length of pygidium; pleural lobes as wide as axial, regularly convex; a short spine extending backward from the narrow marginal border at the posterolateral corners of pygidium; axial and pleural lobes divided by faint furrows into three narrow segments.

Outer surface sparsely covered with coarse granules; inner surface thickly punctate.

This species is the most characteristic form of this fauna and occurs abundantly at all localities. One specimen, though poorly preserved, retains the entire thorax, and so aids in completing the knowledge of the genus.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone).

Types.—Holotype, a cranidium, Y.P.M. 15849; paratype, a cranidium, Y.P.M. 15853; paratype, a pygidium, Y.P.M. 15852; loc. 3, north end of Cow Head Peninsula, just west of Cow Head village. Paratype, specimen with thorax, Y.P.M. 15850, loc. 2, north end of Cow Head Peninsula, just west of Cow Head village. Paratype, a free cheek, Y.P.M. 15851; outer side of Cow Head Peninsula, facing Stearing Island.

TERRANOVELLA Lochman, n. gen.

Cranidium small, with a broad subquadrate glabella; two pairs of short arcuate glabellar furrows; occipital ring with a short, heavy spine; fixed cheeks of medium width; palpebral lobes narrow, situated on transverse median line of glabella; frontal limb wide, very convex; no frontal border; posterolateral limbs short.

Free cheek and pygidium not known.

Genotype.—*Terranovella obscura* Lochman, n. sp.

TERRANOVELLA OBSCURA
Lochman, n. sp.
Plate 56, figures 29–31

Cranidium small with a broad subquadrate slightly convex glabella; two pairs of shallow arcuate glabellar furrows; occipital furrow narrow, well defined at sides but shallow along median line; occipital ring wide and flat, continuing backward into a short, broad spine; dorsal furrow broad, deeply impressed around glabella. Fixed cheeks one-half width of glabella, slightly convex; palpebral lobes of medium size, narrow, situated on the transverse median line of glabella; ocular ridge narrow, straight; frontal limb wide, very convex; no frontal border. Posterolateral limb short and narrow, marked by a broad, shallow intramarginal furrow.

Free cheek and pygidium not known.

Outer surface of test covered with small granules; frontal limb showing the fine radiating venations.

This species is apparently one of the rarer members of the fauna as only a few specimens have been obtained from the collections. No opisthoparian genera like it are known in the early Upper Cambrian, and it is interesting to note that many of the features of the cranidium call to mind a Middle Cambrian genus such as *Utia*.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone).

Types.—Holotype, a cranidium, Y.P.M. 15843, loc. 2, north end of Cow Head Peninsula, just west of Cow Head village. Paratype, a cranidium, Y.P.M. 15844, outer side of Cow Head Peninsula, facing Stearing Island.

NORWOODIA KATHERINA
Lochman, n. sp.
Plate 56, figures 19–21

Cranidium small with a narrow subquadrate convex glabella; a posterior pair of short, straight glabellar furrows; occipital furrow faint, narrow; occipital ring wide and flat, continuing medially into a short, heavy spine; dorsal furrow narrow and shallow, outlining glabella. Fixed cheeks broad, same width as glabella, flat; palpebral lobe small; ocular ridge narrow, well-defined, crossing fixed cheeks in a straight line; frontal limb of medium width, slightly convex, transverse furrow narrow, faint; frontal border very narrow. Posterolateral limbs short and wide with a very short genal spine, and marked by a narrow, shallow intramarginal furrow. Facial suture cutting anterior margin on line with palpebral lobes, curving directly backward to and around palpebral lobes, thence running straight outward to cut lateral margin well in front of genal angle.

Thoracic segments narrow; axial portion convex; pleural lobes flat, with narrow well-defined pleural furrows.

Pygidium transverse, narrow; axial lobe narrow, moderately convex, extend-

ing nearly full length of pygidium, divided by 6 faint furrows into 5 segments and a terminal part; pleural lobes twice the width of axial, slightly convex, divided into 4 narrow segments with deep narrow pleural furrows; narrow, convex marginal border.

Outer surface sparsely covered with small granules.

This species is most like *N. tenera* and a new species from the Bonneterre of Missouri but differs from them in the flatness of the profile of the cranidium and the extremely short genal spines.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone).

Types.—Holotype, a cranidium, Y.P.M. 15832; paratype, a cranidium, Y.P.M. 15835; paratype, a cranidium with part of thorax, Y.P.M. 15833, loc. 3, north end of Cow Head Peninsula, just west of Cow Head village. Paratype, a pygidium, Y.P.M. 15834, outer side of Cow Head Peninsula, facing Stearing Island.

LINGULELLA HOLYOKENSIS
Lochman, n. sp.
Plate 57, figures 34–38

Ventral valve subacuminate in outline; dorsal valve ovate to broadly subcircular; outer shell layer thick, covered with fine growth lines; inner shell layers irridescent, marked by fine growth lines and numerous fine radiating lines; innermost shell layer covered with coarse punctae. Ventral valve, 11½ mm by 7 mm by 1 mm; dorsal valve, 8 mm by 8 mm by 0.75 mm.

Visceral area of ventral valve large, clubshaped, extending almost to median line of valve; muscle scars unknown. Internal markings of dorsal valve unknown.

A large number of *Lingulella* valves, both dorsal and ventral, occur in the collection, and many have the exterior well preserved. However, aside from traces of the visceral area on the ventral valve and one specimen which shows the false interarea on the ventral valve, nothing can be determined of the interior. The species is at present described as new because in shape of shell and external markings it cannot be exactly matched among the described species.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone).

Types.—Holotype, a ventral valve, Y.P.M. 15871; paratype, a dorsal valve, Y.P.M. 15872, loc. 2, north end of Cow Head Peninsula, just west of Cow Head village. Paratypes, dorsal valves, Y.P.M. 15873, 15874, 15875, loc. 3, north end of Cow Head Peninsula, just west of Cow Head village.

ACROTRETA SCHUCHERTI
Lochman, n. sp.
Plate 57, figures 27–29

Ventral valve subcircular, a low cone; beak small, slightly incurved; interarea triangular, narrow, with a median vertical furrow. Dorsal valve perfectly circular, with small beak incurved over narrow interarea to the short straight posterior margin.

One ventral valve showing a portion of the vascular sinuses just below the beak.

Outer surface of both valves covered by innumerable fine growth lines. Shell material chitinous. Inner surface marked by fine radiating lines.

Maximum known size, 2 mm by 2 mm.

Although the internal structures of this form cannot be determined, the extremely low cone of the ventral valve distinguishes the species sharply from all previously described species. It is here described as new although additional material revealing internal markings may prove it to be based upon the immature valves of some known species.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone).

Types.—Holotype, a ventral valve, Y.P.M. 15837; paratype, a dorsal valve, Y.P.M. 15839, loc. 3, north end of Cow Head Peninsula, just west of Cow Head village. Paratype, a ventral valve,

Y.P.M. 15838, loc. 2, north end of Cow Head Peninsula, just west of Cow Head village. Paratype, a dorsal valve, Harvard Museum 8774, northeast side of Cow Head Peninsula.

DENDROGRAPTUS KINDLEI Ruedemann

Plate 57, figure 41

Dendrograptus kindlei RUEDEMANN, *1933*, Milwaukee Public Mus. Bull., vol. 12, no. 3, p. 318, pl. 53, fig. 5; pl. 54, fig. 4.

The collection contains two identifiable graptolite specimens. One is a portion of a rhabdosome, the thecae of which have been filled with pyrite so that their natural convexity has been preserved. The carbonized exoskeleton retains many of the fine concentric growth lines. The other fragment is largely a carbon film and does not show the structure as well.

Occurrence.—Upper Cambrian block in Cow Head breccia (*Crepicephalus* zone) loc. 2, north end of Cow Head Peninsula, just west of Cow Head village.

Figured specimen.—Y.P.M. 15846.

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2. HOWELL, B. F., and MASON, J. F., Correlation of Middle Cambrian faunas of North America: *Jour. Paleontology*, vol. 12, p. 297, 1938.

NOTE: The manuscript of this paper was received by the editor January 3, 1938.

EXPLANATION OF PLATE 56

All figures natural size unless otherwise indicated. The specimens are in the Peabody Museum of Yale University (Y. P. M.) and the United States National Museum (U. S. N. M.).

FIGS. *1–5—Meteoraspis borealis* Lochman, n. sp. *2, 5,* Holotype, cranidium, 5, ×3, Y. P. M. 15849. *3, 4,* Paratype, dorsal and side views of cranidium, Y. P. M. 15853. *1,* Paratype, weathered complete specimen showing thorax, Y. P. M. 15850. Block in Cow Head breccia, north end of Cow Head Peninsula, just west of Cow Head village. (p. 472)

6–8—Tricrepicephalus sp. undet. Dorsal, side and posterior views of pygidium, U. S. N. M. 95169. Outer side of Cow Head Peninsula, facing Stearing Island.

9–11—Welleraspis newfoundlandensis Lochman, n. sp. Holotype, cranidium. *9, 11,* Dorsal and side views ×5; *10,* dorsal view. Y. P. M. 15823. Petit Jardin formation, horizon 38Z24. Outcrop on east flank of anticline on south shore of Cape St. George. (p. 469)

12–15—Talbotina degrasensis Lochman n. sp. *12, 13,* Dorsal and side views of cranidium, holotype, ×5, Y. P. M. 15829. *14, 15,* Dorsal and side views of pygidium, paratype, ×5, Y. P. M. 15828. Petit Jardin formation, horizon 38Z24, outcrop on east flank of anticline on south shore of Cape St. George. (p. 467)

16–18—Talbotina solitaris Lochman, n. sp. *16, 17,* Dorsal and side views of cranidium, holotype, ×5; *18,* dorsal view of holotype, Y. P. M. 15826. Petit Jardin formation, horizon 38Z24, outcrop on east flank of anticline on south shore of Cape St. George. (p. 468)

19–21—Norwoodia katherina Lochman, n. sp. *20,* Dorsal view of cranidium, holotype, ×5, Y. P. M. 15832. *19,* Dorsal view of cranidium, paratype, ×5, Y. P. M. 15835. Block in Cow Head breccia, loc. 3, north end of Cow Head Peninsula, just west of Cow Head village. *21,* Dorsal view of pygidium, paratype, ×5, Y. P. M. 15834. Outer side of Cow Head Peninsula, facing Stearing Island. (p. 473)

22–24—Kingstonia vagrans Lochman, n. sp. *22, 23,* Dorsal and side views of cranidium, holotype, ×5, Y. P. M. 15841. *24,* Dorsal view of pygidium, paratype, ×5, Y. P. M. 15842. Block in Cow Head breccia, loc. 3, north end of Cow Head Peninsula, just west of Cow Head village. (p. 471)

25, 26—Blountia sp. cf. *B. mimula* Walcott. *25,* Dorsal view of small cranidium, ×5, Y. P. M. 15847. Block in Cow Head breccia, loc. 2, north end of Cow Head Peninsula, just west of Cow Head village. *26,* Dorsal view of nearly perfect pygidium, ×5, Y. P. M. 15876. Outer side of Cow Head Peninsula facing Stearing Island. (p. 470)

27, 28—Millardia avitas Walcott. Dorsal and side views of cranidium, ×5, Y. P. M. 15822. Petit Jardin formation, horizon 38Z24, outcrop on east flank of anticline on south shore of Cape St. George. (p. 469)

29–31—Terranovella obscura Lochman, n. gen. and n. sp. *31,* Holotype, cranidium. *29, 30,* Dorsal and side views of holotype, ×5, Y. P. M. 15843. Block in Cow Head breccia, loc. 2, north end of Cow Head Peninsula, just west of Cow Head village. (p. 473)

32–35—Marjumia newfoundlandensis Lochman, n. sp. *32,* Dorsal view of cranidium, holotype. *33,* Dorsal view of pygidium, paratype. *34,* Interior view of free cheek, paratype; all ×2, Y. P. M. 15801. *35,* Hypostoma, ×2, Y. P. M. 15802. March Point formation, horizon 38Z10, near southern tip of March Point about one-fourth mile from Jim Young's wharf, southern shore of Cape St. George. (p. 464)

36–43—Eldoradia dunbari Lochman, n. sp. *36–38,* Dorsal and side view of cranidium, holotype, *36, 38* ×3, Y. P. M. 15804. *43,* Dorsal view of weathered cranidium to show posterolateral limbs, paratype, ×3, Y. P. M. 15807. *39, 40,* Free cheek, paratype, *40,* ×3, Y. P. M. 15805. *41, 42,* A small pygidium, paratype, *42,* ×3, Y. P. M. 15805. *41, 42,* a small pygidium, paratype, *42,* ×3, Y. P. M. 15806. March Point formation, horizon 38Z10, near southern tip of March Point about one-fourth mile from Jim Young's wharf, southern shore of Cape St. George. (p. 465)

Lochman, Cambrian Trilobites

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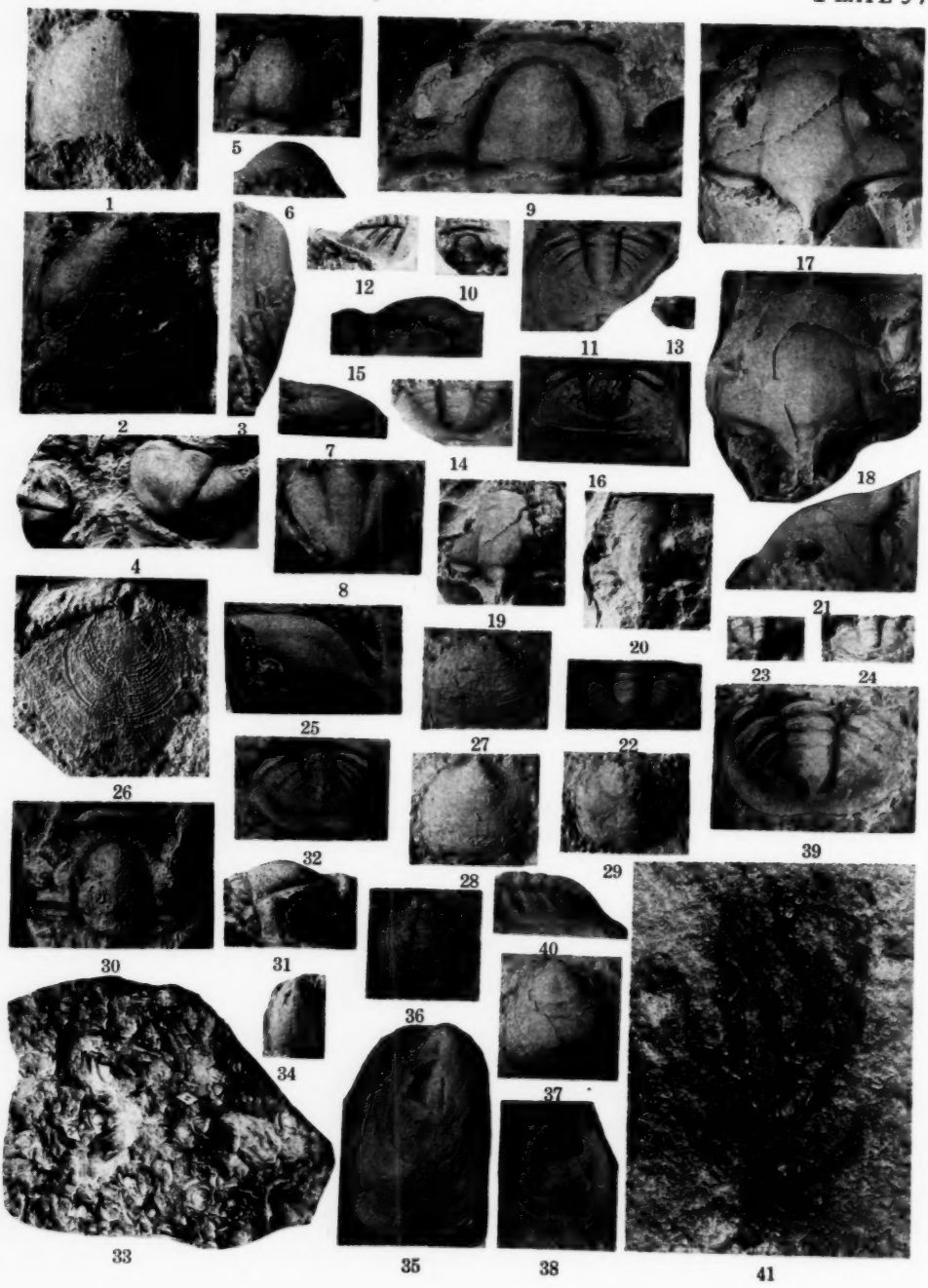

Lochman, Cambrian Fossils

EXPLANATION OF PLATE 57

All figures natural size unless otherwise indicated. The specimens are in the Peabody Museum at Yale University (Y. P. M.) and the Museum of Comparative Zoology at Harvard University (Har. Mus.).

FIGS. *1–3—Dicellomus nanus* (Meek and Hayden). *1*, Broken dorsal valve showing characteristic shell markings, ×8, Y. P. M. 15811. *2, 3*, Upper and side views of complete dorsal valve, ×8, Y. P. M. 15810. Petit Jardin formation, horizon 38Z24, outcrop on east flank of anticline along south shore of Cape St. George. (p. 470)

4—Maryvillia arion Walcott. Two well-preserved pygidia, ×2, Y. P. M. 15821. Petit Jardin formation, horizon 38Z24, outcrop on east flank of anticline on south shore of Cape St. George. (p. 469)

5–8—Kingstonia ara (Walcott). *5, 6*, Dorsal and side views of best preserved cranidium, ×3, Y. P. M. 15860. *7, 8*, Dorsal and side views of pygidium showing inner surface, plesiotype, ×3, Y. P. M. 15861. Petit Jardin formation, outcrop on south shore of Cape St. George near Little Green Gardens. (p. 466)

9–15—Coosella helena Lochman, n. sp. *10*, Nearly complete cranidium, holotype, *15*, Side view of holotype, ×3, Y. P. M. 15814. *9*, A cranidium with the posterolateral limbs, ×3, Y. P. M. 15815. *11, 12*, Dorsal and side views of a large broken pygidium, paratype, Y. P. M. 15818. *13, 14*, A smaller pygidium, paratype, *14*, ×3, Y. P. M. 15816. Petit Jardin formation, horizon 38Z24, outcrop on east flank of anticline on south shore of Cape St. George. (p. 468)

16—Crepicephalus sp. undet. A weathered pygidium showing the characteristic features of this species, Y. P. M. 15845. Block in Cow Head breccia, outer side of Cow Head Peninsula, facing Stearing Island. (p. 471)

17–25—Arapahoia raymondi Lochman, n. sp. *17, 19, 21*, Dorsal and side views of perfect cranidium, showing inner surface, holotype, *17, 21*, ×2, Y. P. M. 15863. *18*, A perfect cranidium showing part of outer surface, paratype, ×2, Y. P. M. 15869. *23*, A perfect pygidium, showing inner surface, Y. P. M. 15864. *22*, A pygidium showing outer surface, paratype, ×3, Y. P. M. 15867. *25*, A perfect free cheek with outer surface preserved, paratype, ×2, 15868. Petit Jardin formation, outcrop on south shore of Cape St. George, near Little Green Gardens. *20*, Dorsal view of a cranidium showing preservation in shale. *24*, Dorsal view of pygidium showing preservation in shale, Y. P. M. 15857, Petit Jardin formation, horizon 38Z23, outcrop on east flank of anticline on south shore of Cape St. George. (p. 466)

26—Lingulella sp. cf. *L. quadrilateralis* (Walcott). Nearly complete valve showing characteristic shape and surface markings, ×2, Y. P. M. 15858. Petit Jardin formation, horizon 38Z23, outcrop on east flank of anticline on south shore of Cape St. George. (p. 470)

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39, 40—Coosia sp. undet. Dorsal and side views of pygidium, ×3, Y. P. M. 15825. Petit Jardin formation, 38Z24, outcrop on east flank of anticline on south shore of Cape St. George. (p. 468)

41—Dendrograptus kindlei Ruedemann. A well-preserved pyritized fragment of a rhabdosome, ×8, Y. P. M. 15846. Block in Cow Head breccia, north end of Cow Head Peninsula, just west of Cow Head village. (p. 475)

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UPPER MIDDLE DEVONIAN RUGOSE CORALS OF THE NEVADA LIMESTONE

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ABSTRACT

This second paper on the rugose corals of the Nevada limestone presents a systematic description of the species occurring between the 500- and the 2400-foot horizons. Representatives of "*Cyathophyllum*" *petraioides* Whiteaves, *Prismatophyllum profundum* (Hall), and *Mesophyllum vesciculosum* (Goldfuss) are illustrated, and new species of "*Cyathophyllum*," *Disphyllum*," *Spongophyllum*, *Prismatophyllum*, and *Mesophyllum* are described.

In my first paper on the rugose corals of the Nevada limestone(1), the general stratigraphic relations of the formation and its faunal succession were noted, and the rugose coral fauna of the basal 500 feet was described. The present paper presents a description of the rugose corals occurring between the 500-foot horizon and the 2400-foot horizon, which has been chosen as the top of the Middle Devonian. The coral assemblage in this sequence is quite distinct from that found in the basal 500 feet of the formation.

The basal 500 feet of the Nevada limestone is composed of a brown and gray shaly limestone and contains a rich fauna that is believed to be of Onondaga age. Between the 500-foot horizon and approximately the 1500-foot level the lithology changes to a light-gray finely crystalline limestone in which the fossils are highly silicified. In this sequence there is a successive series of coral reefs containing "*Cyathophyllum*" *petraioides*, "*Cyathophyllum*" *kobehense*, "*Cyathophyllum*" sp., *Disphyllum occidens*, *Disphyllum lonense*, *Spongophyllum prismatophylloides*, *Prismatophyllum flexum*, *Mesophyllum vesciculosum*, and *Mesophyllum nevadense*, associated with species of the "tabulate" coral genera *Favosites*, *Cladopora*, and *Syringopora*. The great majority of the corals described by Walcott, 1884 (2), came from these beds.

Above the 1500-foot horizon the lithology changes to a dark-gray medium-grained limestone, and the fossils contained in the rocks above this level are not silicified. At the 1600-foot horizon there is a zone containing several species of the brachiopod genus *Martinia*, and about at the 1800-foot level there is a zone containing *Prismatophyllum profundum* in association with the brachiopod *Atrypa missouriensis*. No corals have been found between this horizon and the top of the Middle Devonian, which has been placed at the 2430-foot level because of the occurrence of species of *Stringocephalus* at this horizon.

The corals in these beds show a marked resemblance to those of Hamilton age in eastern North America and in the Mississippi Valley, but there appears to be a total lack of the heliophylloid forms that are so characteristic of the typical Hamilton rugose coral fauna.

I am indebted to the United States Geological Survey and to the Department of Geology of the United States National Museum for the loan of the specimens involved in this study, and to the Department of Geology of Princeton University for furnishing equipment and financial assistance in the preparation of this paper.

SYSTEMATIC DESCRIPTIONS

Genus CYATHOPHYLLUM Goldfuss, 1826

Cyathophyllum GOLDFUSS, *1826*, Petrefacta Germaniae, p. 54.

The species here placed in *Cyathophyllum* are tentatively referred to this comprehensive genus until the generic affinities of this large and complex group are better known.

Genotype: For a discussion of the genotype of *Cyathophyllum* see Lang and Smith, 1929 (3).

"CYATHOPHYLLUM" PETRAIOIDES Whiteaves

Plate 58, figures 2a–c

Cyathophyllum n. sp. WALCOTT, *1884*, U. S. Geol. Survey Mon. 8, p. 105.

Cyathophyllum petraioides WHITEAVES, *1892*, Contr. Canadian Paleontology, vol. 1, pt. 4, p. 265.

Walcott's original description of the specimens is as follows:

> Single conical polyparia, annulated by coarse undulations of growth and longitudinally striated by the septal furrows. The bases of root-like prolongations from the outer surface often obscure these features. Calyx very deep and opening out rapidly. A specimen 35 mm in height has a calyx 22 mm in depth, with a diameter of 26 mm at the margin. Lamellae from 50 to 60 in number. This is a strongly marked form, unlike any other known to me.

The two specimens on which Walcott based his description have been preserved, and the following additional features can be noted: The septa are radially arranged and are little more than striae, never extending more than 1 mm above the calyx walls. As seen in the transverse section they are thin and noncarinate and apparently not differentiated into a major and minor series. Peripherally convex dissepiments are very numerous between the septa. A polished longitudinal section shows zones of axially convex dissepiments occupying the entire space between the inner and outer calyx walls. In the short distance between the base of the calyx and the proximal end of the corallite there are a few short, incomplete tabellae that appear between the converging zones of dissepiments.

These features are apparently identical with those mentioned in the description of *C. petraioides* Whiteaves (see Lambe, 1901, 4) found in the Middle Devonian at several localities in western Canada. The "rootlike prolongations," deep calyx "excavated to within a short distance of the base," and 40 to 60 septa "consisting of mere ridges" are mentioned as characters of this species. In addition the "vesicular tissue" between the calyx walls and the sparsely represented tabulae at the base of the calyx are noted.

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Hypotypes.—U. S. Nat. Mus., 96212.

"CYATHOPHYLLUM" KOBEHENSE Stumm, n. sp.

Plate 58, figures 1a, b; plate 59, figures 1a, b

Cystiphyllum n. sp. WALCOTT, *1884*, U. S. Geol. Survey Mon. 8, p. 106.

External features: The specimens are small curved trochoid simple corals varying from 2 to 4 cm in length and from 1 to 2 cm in diameter at the calyx. The epitheca is well developed and shows numerous concentric growth lines and faint vertical striations. The calyxes are typically erect but occasionally slightly reflexed, producing a bellshaped appearance. There are from 70 to 80 thin, smooth septa visible in the calyx, of which the major continue to the base and the minor die out about half-way down. In parts of the calyxes of some specimens a few of the dissepiments are raised in a blisterlike fashion, producing a structure analogous to that in the calyx of *Mesophyllum*. No evidence of this feature can be seen in the internal structure, and it is possible that this surface appearance may be due to the extreme silicification that the specimens have undergone.

Internal features: In the transverse section of a paratype there are about 80 thin, smooth septa of which the major extend from the periphery almost to the axis, becoming twisted at their axial ends. The alternate minor septa are about one-half as long. Peripherally convex dissepiments are very numerous between the septa up to the axial termination of the minor septa and are more widely separated beyond that point. In the longitudinal section the tabularium averages 1 cm in diameter and is composed of occasional complete tabulae interspersed with many short distally convex tabellae. The peripheral dissepimentarium varies from 3 to 5 mm in diameter and is composed of many rows of fine axially convex dissepiments.

Remarks.—The longitudinal section of this species is very similar to that of *Tabulophyllum*, but there is no trace in the transverse section of a peripheral dissepimentarium, which is characteristic of that genus.

Walcott considered two specimens of this species to be new species of *Cystiphyllum* on the basis of raised dissepiments in parts of the calyxes. Sections taken through Walcott's specimens show that the internal structure is identical with that of "*Cyathophyllum*" *kobehense*.

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Types.—Holotype, U. S. Nat. Mus., 96213a; paratypes, U. S. Nat. Mus., 96213b, c.

"CYATHOPHYLLUM" sp.
Plate 58, figure 3a; plate 59, figures 2a, b

The specimen is a small curved cylindroid coral measuring 2 cm in length and averaging 5 mm in diameter. Weathering has removed the epitheca and has exposed the peripheral edges of the septa. The distal portion including the calyx is missing. In the transverse section there are about 54 thin, smooth septa, of which the major extend from the periphery over two-thirds of the distance to the axis. The alternate minor septa are very short, never extending more than 2 mm from the periphery. Horizontal dissepiments are numerous between the periphery and the axial ends of the minor septa and become separated by greater distances beyond that point. The structure and disposition of the tabulae is not known.

Remarks.—Only one incomplete specimen of this species has been found, and I am deferring any specific designation until more and better specimens become available. The specimen may be a fragment of a phaceloid corallum, and if so the internal features presented would probably place the species under *Disphyllum*. If, on the other hand, the species is simple it will fall into that group of cyathophylloid corals with short, degenerate minor septa.

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Specimen.—U. S. Nat. Mus., 96214.

Genus DISPHYLLUM de Fromental, 1861

Disphyllum DE FROMENTAL, *1861*, Introduction à l'étude des polypiers fossiles, p. 302.

Genotype: By subsequent designation of Lang and Smith, 1935 (5), *Cyathophyllum caespitosum* Goldfuss, 1826 (6*a*), = *Disphyllum goldfussi* Lang and Smith, 1935 (5*a*).

DISPHYLLUM OCCIDENS
Stumm, n. sp.
Plate 59, figures 3a, b

External features: The holotype is a compound corallum composed of ceratoid or trochoid corallites increasing by peripheral budding. In places the walls of neighboring corallites are in contact, giving the corallum a partially cerioid appearance. The corallites are circular in section except where they are in contact, and are extremely variable in size, ranging from a diameter of 5 mm in young individuals to 2.5 cm in those of mature age.

Internal features: In a transverse sec-

tion through the corallum the corallites show from 40 to 60 thin radially arranged septa, of which the major extend almost to the axis and the minor are about two-thirds as long. Both the major and minor septa bear carinae. There are numerous horizontal or peripherally convex dissepiments between the septa, many of which are gathered near the axial terminations of the minor septa to form an indefinite ringlike inner wall that varies from 3 mm to almost 1 cm in diameter in different corallites. In a longitudinal section of a complete corallite the tabulae occupy a central column 6 mm in diameter and are flanked along each side by a narrow column of short periaxial tabellae. The tabulae are horizontal or proximally convex and are separated by distances varying from 0.5 to 1 mm. Wide zones of distally arched dissepiments occupy the regions on either side of the tabularium. These zones range from 2 to 5.5 mm in diameter, increasing toward the distal end of the corallites.

Remarks.—Although this species is closely related to *D. goldfussi* in internal structure, it can be distinguished by the following features: The individual corallites are ceratoid or trochoid instead of cylindroid in growth habit, and therefore the mature corallites are much larger in diameter. The septa are more heavily carinate in *D. occidens*, and the dissepimentarium in this species is much wider, occupying over one-half of the area and confining the tabulae to a narrow axial region.

Occurrence.—Approximately 1000 feet above the base of the Nevada limestone just west of Romano Ranch Mountain, east side of the Sulphur Spring Mountains, Roberts Mountains quadrangle, Nevada.

Holotype.—U. S. Nat. Mus., 96215.

DISPHYLLUM LONENSE Stumm, n. sp.
Plate 58, figure 4a; plate 59, figures 4a–c

Diphyphyllum simcoense WALCOTT *1884* (not *Eridophyllum simcoense* Billings), U. S. Geol. Survey Mon. 8, pp. 105–106.

External features: The corallum is phaceloid, growing in large, irregularly hemispherical masses. Individual corallites are cylindroid, varying from 5 to 11 mm in diameter, and possessing erect calyx walls. They are provided with a heavy epitheca, on which closely spaced horizontal growth annulations are common. There is no vertical striation except where the epitheca has been removed exposing the peripheral terminations of the septa.

Internal features: In the transverse section there are from 24 to 28 thin, smooth septa in the corallites of which the major extend two-thirds of the distance to the axis. The alternate minor septa are short peripheral spines, never extending more than 0.5 mm from the periphery. A single series of dissepiments forms a ringlike inner wall about 1 mm from the periphery. A few scattered dissepiments occur between this wall and the axial ends of the major septa. The tabulae, as seen in the longitudinal section, are usually horizontal and complete, occasionally incomplete with periaxial tabellae. They are bounded on either side by a single row of large axially convex dissepiments.

Remarks.—*Eridophyllum simcoense*, with which Walcott compared this species, is a smaller form in which the corallites range from 3 to 6 mm in diameter, and bear carinate septa. Typical specimens of *E. simcoense* have many "connecting processes." Those forms not showing this feature have usually been known under the name *Diphyphyllum stramineum* Billings.

The corallites of *Disphyllum lonense* are normally twice the diameter of these species and are further distinguished by the noncarinate septa, the much shorter minor septa, and the total absence of any "connecting processes."

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Holotype.—U. S. Nat. Mus., 96216.

Genus SPONGOPHYLLUM Edwards and Haime, 1850

Spongophyllum EDWARDS and HAIME, *1850*, A monograph of the British fossil corals, p. 425.

Genotype: By monotypy, *Spongophyllum sedgwicki* Edwards and Haime (7).

SPONGOPHYLLUM PRISMATOPHYLLOIDES Stumm, n. sp.

Plate 58, figure 5a; plate 59, figures 5a, b

Cyathophyllum davidsoni WALCOTT, *1884*, (not *Acervularia davidsoni* EDWARDS and HAIME) U. S. Geol. Survey Mon. 8, p. 104.

External features: The holotype is a portion of a hemispherical cerioid corallum in which the pentagonal or hexagonal corallites range from 5 mm to 2 cm in diameter. The calyces range from 3 to 5 mm in depth and the calyx walls are erect or slightly reflexed.

Internal features: A transverse section shows an average of 30 thin, smooth septa in the individual corallites, of which the major extend to the axis. The minor septa are very irregular in habit, sometimes appearing as short peripheral spines or as discontinuous septal crests, at other times entirely lacking. In most places the septa do not extend to the periphery, and the intervening space is occupied by rows of irregularly shaped dissepiments. Additional horizontal or peripherally convex dissepiments occur between the septa. The tabularium is poorly defined by a stopping of the dissepiments at a point approximately midway between the periphery and the axis. In the longitudinal section the tabularium averages 5 mm in diameter and is occupied by closely set incomplete tabulae. On either side are zones of small distally arched dissepiments.

Remarks.—This species shows a marked resemblance to *Spongophyllum cyathophylloides* Etheridge, Jr., 1911 (8), from the Clermont limestone of Queensland. The average size of the corallites in *S. prismatophylloides* is larger, the minor septa are much more irregular in habit, and the peripheral zones of dissepiments are not as evenly developed as they are in the Australian species. Neither of these species have the complete tabulae and single row of peripheral dissepiments in the longitudinal section that are characteristic of the genotype of *Spongophyllum*, but the peripheral dissepimentarium and irregular minor septa as seen in the transverse section are highly characteristic of the genus.

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Holotype.—U. S. Nat. Mus., 96217.

Genus PRISMATOPHYLLUM Simpson, 1900

Prismatophyllum SIMPSON, *1900*, New York State Mus. Bull., vol. 8, p. 218.

Genotype: By original designation of Simpson, *Cyathophyllum rugosum* Edwards and Haime, 1851 (10) = *Prismatophyllum prisma* Lang and Smith, 1935 (5*b*).

PRISMATOPHYLLUM PROFUNDUM (Hall)

Plate 59, figures 7a, b

Acervularia profunda HALL, *1858*, Iowa Geol. Survey Rept., vol. 1, pt. 2, p. 477.

Two specimens from the Nevada limestone are apparently conspecific with this well known species from the Cedar Valley limestone of Iowa. In the Nevada specimens the peripheral portions of the calyxes are slightly more reflexed, causing the "central pits" to be more heavily defined, but in the internal characters they cannot be distinguished from typical examples of Hall's species.

In the transverse section there are 36 septa in the mature corallites, of which the major extend to the axis, often becoming twisted at their axial ends. The alternate minor septa are about one-half as long. All the septa are heavily carinate, and the spaces between them are filled with numerous horizontal dissepiments. The corallites range from 3 mm to over 1 cm in diameter, and their walls are irregularly polygonal, often curved, and

very unequal in size so that a corallite may have a diameter of 1 cm in one direction and 5 mm in a direction at right angles to this. Young corallites are almost circular in outline. In the longitudinal section the central tabularium averages 4 mm in diameter and is composed of closely set complete and incomplete tabulae. The peripheral dissepimentarium ranges from 2 to 4 mm in diameter and is composed of several rows of fine distally arched dissepiments.

Occurrence.—Approximately 1800 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Hypotypes.—U. S. Nat. Mus., 96218.

PRISMATOPHYLLUM FLEXUM
Stumm, n. sp.
Plate 58, figures 6a–d; plate 59, figures 6a–c

Cyathophyllum rugosum WALCOTT, *1884*, (not Edwards and Haime) U. S. Geol. Survey Mon. 8, p. 104.
Cyathophyllum n. sp. WALCOTT, idem, pp. 104, 105.

External features: This species is quite variable in external appearance, showing all gradations between a phaceloid and a cerioid growth form. The condition is produced by profuse budding from the reflexed parts of the calyxes of mature corallites. In many parts of a corallum such budding has produced as many as 10 young corallites around one of mature size. These grow in a phaceloid form until increase in their diameters causes them to assume the cerioid habit. The holotype is a complete hemispherical corallum showing a variation from 3 mm to over 2.5 cm in the diameters of the corallites. Young corallites are usually phaceloid with erect calyx walls, and the mature ones are cerioid with reflexed calyxes. Small false columellas are produced at the bases of the calyxes by elevation of the axial ends of the major septa.

Internal features: In the transverse section there are from 50 to over 60 thin septa in the mature corallites, of which the major extend to the axis where they frequently become twisted, forming an anastomosing network. The minor septa are about two-thirds as long. Most of the septa in this species are typically noncarinate, although small irregularities in a few of them give them a slightly crenulated appearance. The walls are strong and roughly polygonal, but are very irregular in their relative lengths and usually show a marked curvature. Peripherally convex dissepiments are very numerous between the periphery and the axial terminations of the minor septa. In the longitudinal section the tabularium averages about 5 mm in diameter and is composed of horizontal or gently arched tabulae bounded on each side by a single row of tabellae. On each side of the tabularium are zones of varying width composed of distally arched dissepiments.

Remarks.—Walcott considered the more cerioid specimens of this species to be conspecific with *Cyathophyllum rugosum* Edwards and Haime, but the lack of typical carinae, the greater variation in size of the corallites and the marked curvature of the walls are all features which, in addition to the unusual growth habit, serve to distinguish *P. flexum* from *C. rugosum.*

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Types.—Holotype, U. S. Nat. Mus., 96219a; paratypes, U. S. Nat. Mus., 96219b, c, d.

Genus MESOPHYLLUM
Schlüter, 1889

Mesophyllum SCHLÜTER, *1889*, Abh. geol. Specialkarte Preussen, vol. 8, pt. 4, p. 75.

Genotype: By subsequent designation of Wedekind, 1925 (12), *Mesophyllum defectum*, Schlüter, 1889 (11), = *Cyathophyllum vesciculosum* Goldfuss, 1826 (6*b*), = *Cystiphyllum vesciculosum* auctt.

MESOPHYLLUM VESCICULOSUM
(Goldfuss)
Plate 59, figures 8a, b

The hypotype is the central portion of

a simple, cylindroid coral on which all the external features have been removed by weathering. The average diameter of the specimen is 5 cm. A transverse section shows a series of small axially convex dissepiments that continue with relatively no change in size or habit from the periphery to the axis. These small crescentshaped dissepiments enclose spaces ranging from 1 to 3 mm in diameter. There is no visible differentiation into a peripheral dissepimentarium and an axial tabularium. No septal crests are visible in the section. In the longitudinal section the dissepiments are axially convex and similar in size and habit across the entire diameter of the specimen.

In internal structure the specimen is not distinguishable from typical forms of *M. vesiculosum* from strata of Hamilton age in eastern North America. The small average size of the dissepiments and the similarity in structure of the dissepimentarium and the tabularium are very diagnostic of the species.

Walcott (2) noted the occurrence of this species in the Nevada limestone under the name *Cystiphyllum americanum* Edwards and Haime. *C. americanum* is considered to be conspecific with *M. vesciculosum*. The specimen on which Walcott based his determination has not been found.

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Hypotype.—U. S. Nat. Mus., 96220.

Mesophyllum nevadense
Stumm, n. sp.
Plate 58, figures 7a, b; plate 59, figure 9a

External features: The holotype is a simple curved cylindroid coral measuring 6 cm in length and varying from 3 to 4 cm in diameter. The proximal end of the specimen is missing and the calyx is incomplete. There is a heavy, strongly annulated epitheca, on which vertical striations are very faint or entirely lacking. A paratype shows a well-preserved calyx measuring 1.5 cm in depth. The calyx is in the shape of an inverted cone with a pointed base and bears large elevated dissepiments along its sides. These dissepiments average 4 mm in diameter and are surmounted by faint, usually incomplete septal crests.

Internal features: In the transverse section large evenly developed dissepiments occur without change in habit between the periphery and the axis. These dissepiments are unusually large, enclosing spaces that average 4 mm in diameter. No distinction can be made between the dissepimentarium and the tabularium. Distinct septal crests cannot be seen in the section. In the longitudinal section the dissepiments are

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Explanation of Plate 58

All figures natural size

Figs. *1a, b*—*"Cyathophyllum" kobehense* Stumm, n. sp. *1a*, Side view of holotype; *1b*, view of calyx of paratype. (p. 479)

2a–c—*"Cyathophyllum" petraioides* Whiteaves. *2a*, Side view of hypotype; *2b*, other side of same specimen showing depth of calyx; *2c*, side view of other hypotype showing "rootlike projections." (p. 479)

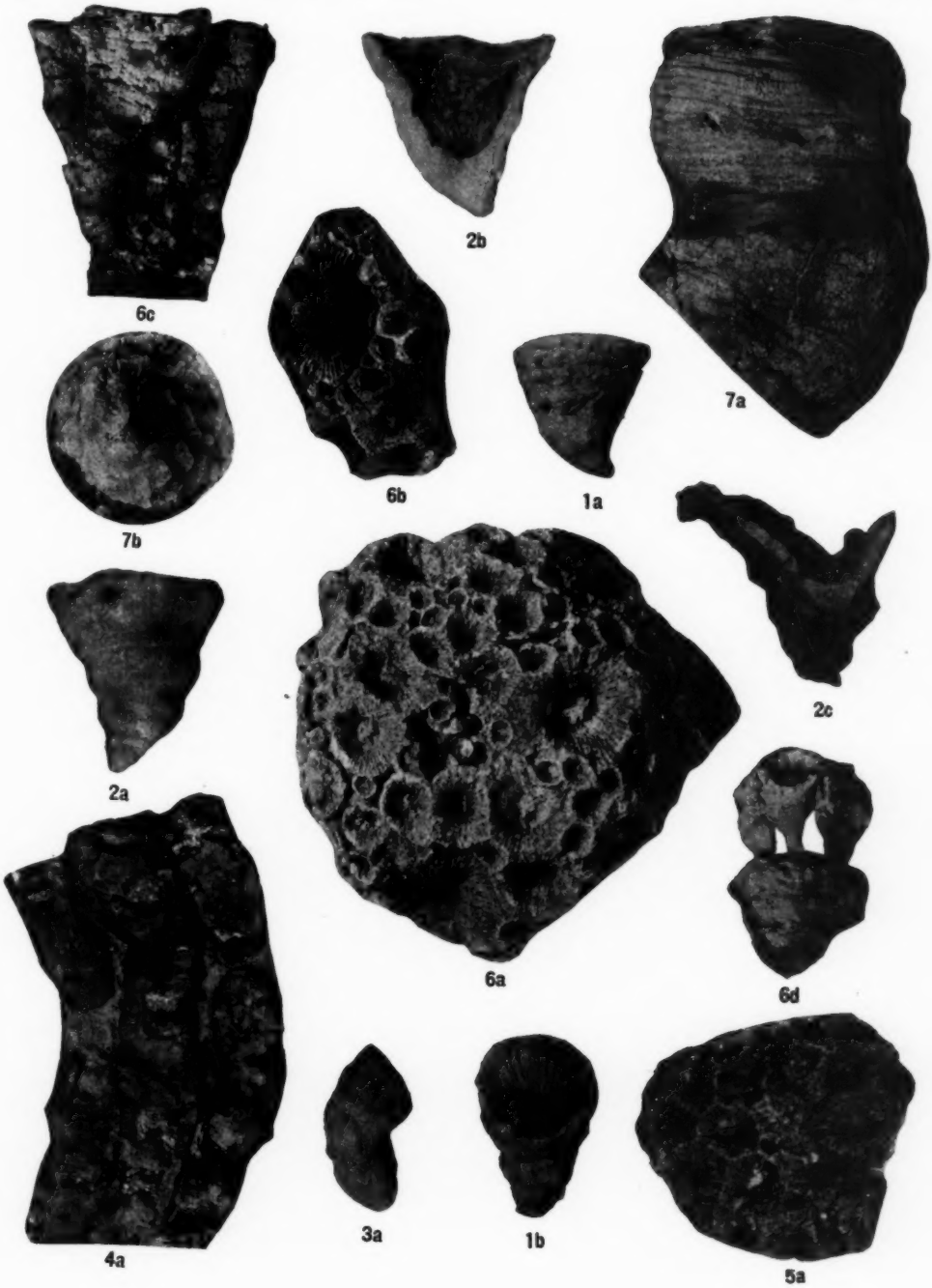
3a—*"Cyathophyllum"* sp. Stumm. Side view of specimen. (p. 480)

4a—*Disphyllum lonense* Stumm, n. sp. Side view of a portion of holotype. (p. 481)

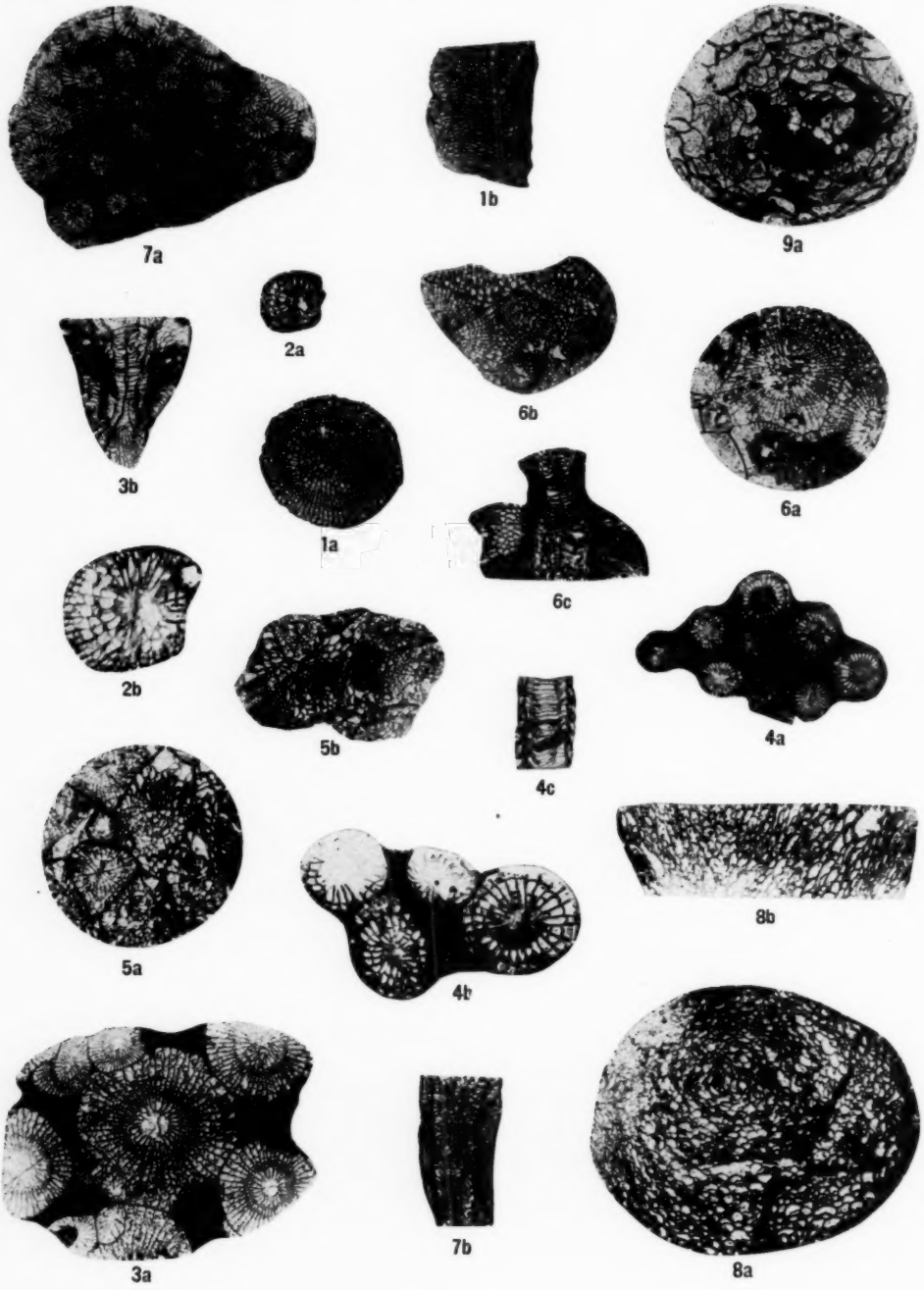
5a—*Spongophyllum prismatophylloides* Stumm, n. sp. Distal view of holotype. (p. 482)

6a–d—*Prismatophyllum flexum* Stumm, n. sp. *6a*, Distal view of holotype; *6b*, view of paratype showing growth of young corallites; *6c*, side view of another paratype showing phaceloid stage; *6d*, one mature corallite of paratype showing young corallites budding from reflexed portions of calyx. (p. 483)

7a, b—*Mesophyllum nevadense* Stumm, n. sp. *7a*, Side view of holotype; *7b*, view of calyx of paratype. (p. 484)



Stumm, Devonian Corals



Stumm, Devonian Corals

evenly developed and axially convex. There is no variation in size between the periphery and the axis.

Remarks.—*Mesophyllum nevadense* has an internal structure similar to that of *M. vesciculosum* with the exception that the individual dissepiments in the former average three times the size of those in the latter. The dissepiments in M. *nevadense* are much larger than those in any other species of *Mesophyllum* I have seen.

Occurrence.—From 700 to 1500 feet above the base of the Nevada limestone at Lone Mountain, 18 miles northwest of Eureka, Nevada.

Types.—Holotype, U. S. Nat. Mus., 96221a; paratype, U. S. Nat. Mus., 96221b.

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EXPLANATION OF PLATE 59

FIGS. *1a–b*—"*Cyathophyllum*" *kobehense* Stumm, n. sp. *1a*, Transverse section. of a paratype, natural size; *1b*, longitudinal section of a paratype, ×1. (p. 479)

2a–b—"*Cyathophyllum*" sp. Stumm. *2a*. Transverse section, ×1; *2b*, same, ×2. (p. 480)

3a–b—*Disphyllum occidens* Stumm, n. sp. *3a*, Transverse section of holotype, ×1; *3b*, longitudinal section of one of the corallites of holotype, ×1. (p. 480)

4a–c—*Disphyllum lonense* Stumm, n. sp. *4a*, Transverse section of holotype, ×1; *4b*, same, ×2; *4c*, longitudinal section of holotype, ×1. (p. 481)

5a–b—*Spongophyllum prismatophylloides* Stumm, n. sp. *5a*, Transverse section of holotype, ×1; *5b*, transverse section of holotype, ×1, showing irregular corallites. (p. 482)

6a–c—*Prismatophyllum flexum* Stumm, n. sp. *6a*, Transverse section of holotype, ×1; *6b*, transverse section of paratype, ×1, showing young corallites; *6c*, longitudinal section of paratype, ×1. (p. 483)

7a–b—*Prismatophyllum profundum* (Hall). *7a*, Transverse section of hypotype ×1; *7b*, longitudinal section of hypotype, ×2. (p. 482)

8a–b—*Mesophyllum vesciculosum* (Goldfuss). *8a*, Transverse section of hypotype, ×1; *8b*, longitudinal section of hypotype, ×1. (p. 483)

9a—*Mesophyllum nevadense* Stumm, n. sp. Transverse section of holotype, ×1. (p. 484)

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NEW GENERA OF OSTRACODERMS FROM THE UPPER SILURIAN OF OESEL

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ABSTRACT

Trematáspis mickwitzi Rohon, 1892, includes two species, *Saaremaaspis mickwitzi* (Rohon) Robertson and *Rotsiküllaspis obrutchevi* Robertson, n. gen., n. sp. *Saaremaaspis* Robertson, 1938, and *Rotsiküllaspis* n. gen. are described.

In his comprehensive description of the Thyestidae and Trematáspidae from the Upper Silurian of Oesel in 1892 (1) Rohon described a new species, *Trematáspis mickwitzi*, including under it Pander's *Dictyolepis bronnii* and in part his *Dasylepis keyserlingii*. He stated that the holotype, an impression of a dorsal shield collected by Fr. Schmidt, had seemed to him to differ sufficiently from *Trematáspis* and from *Thyestes* to justify placing it in a new genus. A specimen collected some years later by Mickwitz, however, this time part and counterpart of a ventral shield, seemed to indicate a similar ornamentation, and Rohon believed that the form of the posterior margin of the oralobranchial chamber in this specimen resembled that of *Trematáspis* too closely to come under a different genus. On the strength of this similarity he described it as *Trematáspis mickwitzi*. In a supplementary paper on the Trematáspidae in 1894 (2) Rohon published a new figure of this species but gave no new data. No further description of the species has been published.

During the past two years I have been working through the abundant material of *Trematáspis* in the collection of the late Dr. Wm. Patten at Dartmouth College. Among the material of that collection were some specimens which had been sent to him a year or so before his death from Fr. Schmidt's collection, among them the specimen figured on Page 70 of Rohon's "Die obersilurischen Fische von Oesel" (1), and as plate 1, figure 17, in his "Zur Kenntniss der Trematáspiden" (2). There are also a few additional specimens among the material collected by Dr. Patten on his own expeditions.

Dr. Dm. V. Obrutchev of the Institut Paleozoologique of the Academie des Sciences de l'U.R.S.S. at Moscow kindly sent me some photographs of other specimens in the Schmidt collection, and in a letter stated that in his opinion "this species has nothing to do with the genus *Trematáspis*." He based his opinion on the relative shortness of the shields, the granular character of the shield surface, and the fact that the lateral fields are single rather than paired as in *Trematáspis*.

The granular character of the surface was noted by Rohon. The relative shortness and broader posterior truncation of the dorsal shield are well shown in plate 1, figure 17, of his 1892 paper. Further differences from *Trematáspis* shown in this figure are: the position of the nasohypophysial pit, the position and length of the dorsal field, and the location of the crista. The latter two points are mentioned by Rohon in his text.

The shield in this figure also appears slightly cornuate, though it shows no pectoral sinuses, the posterior corners of the shield being only slightly more produced than in *Trematáspis*, and the contour of the posterior margin of the dorsal shield being nearly straight save for the median angle and these corners. The lateral fields were neither figured nor de-

scribed by Rohon. A photograph of the holotype sent to me by Dr. Obrutchev (pl. 60, fig. 8) shows the right lateral field, which is single and elongated. This photograph also shows a definite left cornu.

In Rohon's paper three other specimens besides the holotype were assigned to this species. In Dr. Patten's collection there are several specimens that resemble at least one of these, the specimen figured as plate 1, figure 18. As mentioned earlier I have the counterpart of this specimen, which was also figured on page 70 of the 1892 paper and as plate 1, figure 17 of the 1894 paper.

Comparison of the photograph of the holotype with the specimens in this collection show that Rohon's species was really composite. The ornamentation of the holotype, which shows only the dorsal surface, is preserved only in spots but sufficiently to demonstrate its difference from that of specimen 257/566 (pl. 60, fig. 2). This alone would not be sufficient to separate the specimens, for one is a dorsal aspect, the other a ventral. *Thyestes verrucossus* and *Dartmuthia gemmifera* both have quite distinct dorsal and ventral ornamentation. However there is one specimen in the Patten collection, T. 258, (pl. 60, fig. 7) which shows a ventral aspect on which the ornamentation is very similar to that of the holotype.

The more significant differences between the holotype and these other specimens are in proportions. The holotype is broader in proportion to its length, the form of the lateral margins is different, and the cornua are considerably longer. These differences can be readily observed by comparing plate 60, figure 8, the holotype, with specimen T. 135 (pl. 60, fig. 5) of the Patten collection.

Rohon's *Trematapis mickwitzi* must therefore be split into two species. One of these is represented by the holotype and by specimen T. 258 of the Patten collection. The other species is represented by specimen 257/566 of the Paleozoological Museum, Academy of Sciences of U.S.S.R. and by 25 specimens, most of them fragmentary, in the Patten collection at Dartmouth College. The specific designation must go with the holotype.

Since certain of its characters as exhibited by the holotype bar it from the genus *Trematapis* and from the family Trematapidae, I have removed this species from both in a paper on the Trematapidae (3). The question of generic and specific name involved Rohon's *Trematapis mickwitzi* and Pander's *Dictyolepis bronnii* and *Dasylepis keyserlingii*. The Pander species were founded on minute fragments. Rohon's holotype, on the other hand, was quite adequate, and it seemed to me that less inconvenience would result from giving a new generic name and retaining Rohon's specific designation and holotype, than would result from restoring Pander's generic and specific names and very fragmentary holotype. Therefore, in the paper referred to above I gave a new generic name derived from the Estonian name for Oesel, Saaremaa, the species becoming *Saaremaaspis mickwitzi* (Rohon).

The second species is undescribed and quite distinctive. In certain of its characteristics it resembles trematapids. For example, the dorsal and ventral shields are fused marginally, the oralobranchial plates are relatively large and few, and the general form is more trematapidlike. It has other features which differ from that group, such as the single lateral fields and the position of the nasohypophysial pit. As will be brought out more in detail later, this species does not appear to fit into any described genus. I am consequently erecting another genus, *Rotsiküllaspis* (named from the town of Rotsiküll near which it was found) for its reception and am giving it the specific designation *obrutchevi* in honor of Dr. D. Obrutchev of the Academy of Sciences of the U.S.S.R.

The identification of Pander's *Dasylepis keyserlingii* and *Dictyolepis bronnii*

with "*Trematapsis mickwitzi*" was made on the basis of the ornamentation. Since this is closer to that of *Rotsiküllaspis obrutchevi* than to that of *Saaremaaspis mickwitzi*, these forms are probably synonymous with the former.

SYSTEMATIC DESCRIPTIONS

Genus SAAREMAASPIS Robertson, 1938

Saaremaaspis ROBERTSON, *1938*, Am. Jour. Sci., 5th ser., vol. 35, p. 288.

Genotype, *Trematapsis mickwitzi* Rohon. The genus is characterized by the shortness of the lateral fields, especially their posterior extent, the short, broad interzonal part of the shield, relatively short cornua, and broad oralobranchial chamber. The genotype is especially distinguished by its ornamentation of fine granular microscopic tubercles.

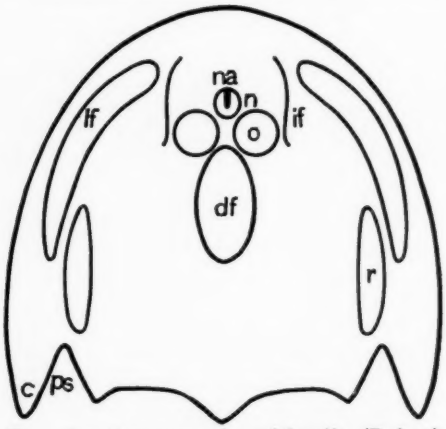

FIG. 1.—*Saaremaaspis mickwziit* (Rohon). Restoration of dorsal aspect × ca. 2. Drawing made under author's direction by Dr. Hannah Croasdale. c, Cornu; df, dorsal field; if, infraorbital canal; lf, lateral field; n, nasohypophysial fossa; na, nasohypophysial aperture; o, orbit; ps, pectoral sinus; r, ridge.

Saaremaaspis is assignable to the Cephalaspidae, but diagnostic features are lacking for assignment to one or another of the subfamilies erected by Stensiö. However, as it comes closer in the observable structures to *Thyestes* than to any other genus, it should probably be classed under the Kiaeraspinae.

SAAREMAASPIS MICKWITZI (Rohon) Plate 60, figures 7, 8; text figure 1

Trematapsis mickwitzi ROHON, *1892*, Acad. imp. Sci. St. Petersbourg Mém., ser. 7, vol. 38, p. 56, pl. 1, fig. 17 (not pl. 1, figs. 12, 19; pl. 2, fig. 13).

Saaremaaspis mickwitzi ROBERTSON, *1938*, Am. Jour. Sci., 5th ser., vol. 35, p. 288.

The anterior end is bluntly rounded, the shield widening to its greatest breadth near the level of the posterior end of the dorsal field, posterior to which it narrows slightly, thus making the cornua slightly incurved at the tips. The length of the shield from the rostral margin to the end of the median angle of the posterior margin is about 18 mm, the maximum width is about 19 mm. The

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EXPLANATION OF PLATE 60

FIGS. *1–6*—*Rotsiküllaspis obrutchevi* Robertson, n. sp. *1*, Part and counterpart of T. 283, Patten collection, showing oralobranchial plates, ×1; *2*, 257/566 Paleontological Museum U.S.S.R. Acad. Sci., Moscow, part of venter, showing part of posterior margin of oralobranchial chamber, ×2, photograph courtesy of Dr. D. Obrutchev: *3*, T. 577 Patten collection, caudal fin, ×1; *4*, T. 133 Patten collection, posterior margin of oralobranchial chamber with branchial notches, ×1; *5*, holotype, T. 135 Patten collection, ventral aspect, with interior of dorsum anteriorly, ×1; *6*, T. 283 Patten collection, same specimen as *1* with core removed to show impression of dorsal shield, broken at lower right, revealing a trace of *Thyestes verrucossus*, ×2.

7, 8—*Saaremaaspis mickwitzi* (Rohon). *7*, T. 258 Patten collection, venter, with interior of dorsum anteriorly, ×1; *8*, holotype, 256/536 Paleontological Museum U.S.S.R. Acad. Sci., Moscow, dorsal aspect, ×2, photograph courtesy of Dr. D. Obrutchev.

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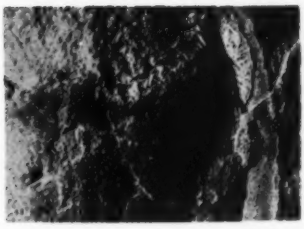

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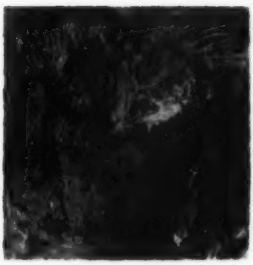

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Robertson, Silurian Ostracoderms

UNIV. OF MICH.

posterior margin has the relatively short cornua, whose length is contained in the distance from the rostral margin to the cornua tip about 5½ times. The pectoral sinuses are fairly deep and narrow, but without any angles on either margin marking them off from the space between cornua and interzonal part of the shield. The cornua are relatively broad, their basal width being about four-fifths of their length. The posterior margin central to the sinuses is very slightly concave and is directed a trifle posteriorly. The median angle is broad and projects behind the general margin about as far as do the cornua tips.

The orbits are rather large proportionately, about 2 mm in diameter, and nearly circular in outline. They are situated about 4.5 mm behind the rostral margin, thus approximately one-third of the distance from the anterior margin to the level of the pectoral sinuses. (I have adopted this ratio as a standard measurement for cephalaspids, since this level is more often available than is the posterior border of the shield, differences in length of the median angle are discounted, and it is more comparable anatomically for different species and genera than would be a ratio including the entire length of the shield.) In our species the orbits are relatively far forward.

The nasohypophysial pit is located in part between the anterior portions of the orbits. The pineal aperture is not preserved, but the form of the "pineal saddle" (3) is trematapidlike. Its exact dimensions are not available because the borders of the dorsal field are not sharp in the specimen. It is approximately 4.75 mm long by 2.5 mm wide.

The lateral fields are relatively short, their anterior ends being about 2.6 mm behind the rostral border, their posterior ends lateral to the posterior end of the dorsal field, about 4.5 mm anterior to the pectoral sinus level. They are about as short anteriorly as in *Thyestes* and shorter posteriorly than in any cephalaspid yet known. They are a trifle over 8 mm in length and about 1 mm wide. Their anterior margins are blunt, their posterior ends pointed. They run practically parallel to the lateral margin of the shield. Just central to their posterior fourth are prominent longitudinal ridges, about 5.25 mm long by 1 mm wide, extending back to within about 1 mm of the sinus level.

Almost the entire extent of the infraorbital sensory canal is visible. It curves inward posteriorly, following the contour of the orbit rim. Anteriorly its course is nearly directly forward to a point about 1.5 mm anterior to the orbit, where it turns slightly inward. It cannot be followed centrally to this.

Specimen T. 258 (pl. 60, fig. 7) shows an incomplete venter of this species with the inner aspect of the dorsal shield in the posterior portion of the oralobranchial chamber. The form of the posterior margin of this chamber differs from that of *Trematapis* in having a relatively small median angle, about 3.5 mm wide by 1.5 mm long, and having the rows of branchial apertures slanting forward at a less acute angle. The apertures themselves are not preserved. No special features are shown by the venter posterior to the chamber. The ornamentation is faintly visible in some parts.

The interior of the dorsal shield is partly preserved, but only traces of structure can be made out. In the midline is a well-preserved portion of the notochordal canal.

Holotype.—U.S.S.R. Acad. Sci. at Moscow, Paleozoological Museum, 256/536.

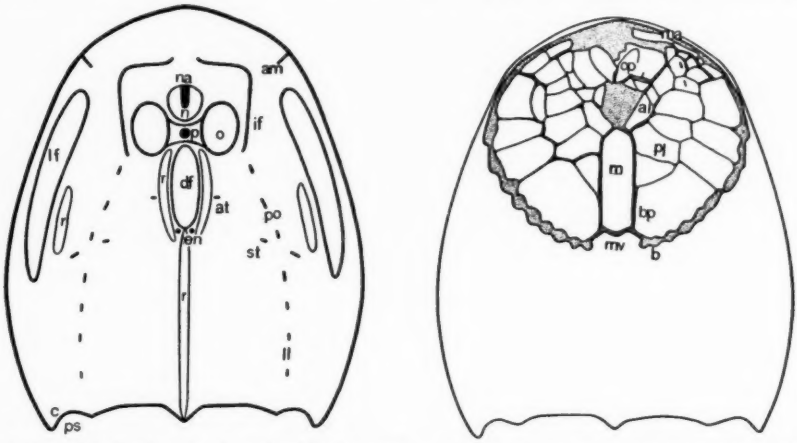
Genus ROTSIKÜLLASPIS Robertson, n. gen.

Genotype, *Rotsiküllaspis obrutchevi* Robertson, n. sp.

Rotsiküllaspis, known only from the genotype, differs from Cepahalaspidae in the thinness of the shield, the firm union of dorsal and ventral shields marginally, and the relatively large size of the oralobranchial plates. It resembles

the Cephalaspidae in the possession of single lateral fields and a nasal fossa set between the anterior parts of the orbits. The nearest approach among the Ostreostraci is the Dartmuthiidae, and from *Dartmuthia* it differs in the firmer marginal fusion of the shields, the greater length of the lateral fields, much slighter ossification, and slight cornua. Whether it represents a new family I am as yet undecided. I am deferring that problem for treatment in a taxonomic review of the order.

Small Ostreostraci with a shield about 30 mm long by 25 mm wide. The shield is thin, ornamented with fine granules not arranged in pattern. Dorsal and ventral shields are closely fused at their lateral margins as in Trematapidae. The shield is slightly cornuate, but the minute cornua are probably not homologous with those of Cephalaspidae. The lateral fields are single, of medium length, not extending to the cornua and lacking a posteromedian angle. The dorsal field is lenticular and bordered laterally by



FIGS. 2, 3.—*Rotsikŭllaspis obrutchevi* Robertson, n. sp. Restoration of dorsal shield (left) and venter (right), × ca. 2. Drawings made under author's direction by Dr. Hannah Croasdale. al, Anterior lateral series of plates; am, anterior marginal canal; at, anterior transverse canal; b, branchial apertures; bp, branchial plates; c, cornu; df, dorsal field; en, endolymphatic aperture; if, infraorbital canal; lf, lateral field; ll, lateral line canal; m, median plate; ma, marginal plates; mv, median ventral process; n. nasohypophysial fossa; na, nasohypophysial aperture; o, orbit; op, oral plate; p, pineal; pl, postlateral series of plates; po, postorbital canal; ps, pectoral sinus; r, ridge; st, supratemporal canal.

ROTSIKŬLLASPIS OBRUTCHEVI
Robertson, n. sp.

Plate 60, figures 1–6; text figures 2, 3

Trematapis mickwitzi ROHON (part), *1892*, Acad. imp. Sci. St. Petersbourg Mém., 7th ser., vol. 38, p. 56, pl. 1, figs. 12, 19 (not fig. 17); pl. 2, fig. 13.—ROHON, *1894*, Acad. imp. Sci. St. Petersbourg Bull., vol. 1, p. 197, pl. 1, fig. 17.

?Dictyolepis bronnii PANDER, *1856*. Monographie der fossilen Fische des Silurischen Systems der russisch-baltischen Gouvernements, p. 56, pl. 5, figs. 5a–e.

?Dasylepis keyserlingii PANDER (part), *1856*, idem, p. 56, pl. 5, figs. 6i–m, (not pl. 5, figs. 6a–h).

ridges that do not meet the crista but are separated from it by spaces in which occur the endolymphatic apertures. The orbits are large and oval. The nasal fossa is large, circular, and deep, with the foramen piercing the anterior wall. The tubercles of the ornamentation are present in the fossa. The infraorbital canal does not reach the lateral fields. The oralobranchial plates are large.

Occurrence.—Upper Silurian, Middle Ludlow, in the Wita quarry near Rotsiküll, Oesel.

Holotype.—Patten collection, T. 135.

Form and ornamentation.—The form of the shield in this genus and species is more similar to that found in *Trematas-pis*, *Oeselaspis*, and *Didymaspis* than to that in *Cephalaspis*. The anterior end is more sharply rounded than in *Saarema-aspis*. The length is about 30 mm, the maximum breadth, slightly over half way back on the shield, about 25 mm. Behind this it narrows until it is about 20 mm wide at the posterior end. The extreme lateral part of the posterior margin is available in two specimens, both ventral shields, and these seem to indicate minute cornua, about 1 mm long (fig. 4). The anatomical position of these cornua would hardly indicate homology with those of cephalaspids. They enclose slight bays ("sinuses"), medial to which there are short posterior projections, and then the more nearly straight transverse margin to a blunt ventral median angle. One specimen, T. 135, shows a trace of deeper structure lying posterior to the bay on one side, but I am of the opinion that it is a detached fragment from some other form rather than a trace of an appendage.

On the dorsal surface there is a longitudinal ridge about 5 mm long on each side similar to that found in *Saarema-aspis mickwitzi*, paralleling the inner border of the lateral field from about its middle back to the supratemporal line of the sensory canal system. A sharp, high median dorsal crista extends backward from the posterior end of the dorsal field, ending in a backwardly directed median process, possibly a spine, from the posterior margin. Ridges also occur along the lateral margins of the dorsal field, but instead of converging and joining the crista as do those found on some cephalaspids, such as *Cephalaspis acadica*, they extend for a short distance behind the dorsal field, paralleling the crista, with the large endolymphatic apertures between them (pl. 60, fig. 6). These ridges are surmounted in places by rounded elevations or tubercles.

The oralobranchial chamber occupies the anterior half of the ventral shield. Posterior to the chamber the ventral and dorsal shields are marginally fused as in *Trematas pis*. At the posterior margin there is no trace of an anal plate such as is found in *Trematas pis*. It seems probable that in *Rotsiküllaspis* the posterior margin of the shield did not mark the posterior extent of the trunk. On the venter there appear longitudinal ridges near the lateral margins, extending from a short distance behind the oralobranchial chamber to the inner ends of the "sinuses." The lateral part of the ventral shield is flattened except for these ridges, forming a sort of rim. Medial to the ridges the shield is arched (pl. 60, fig. 5).

The surfaces of both dorsal and ventral shields and of the plates over the oralobranchial chamber are ornamented with fine, microscopic granular tubercles, looking like a coat of fine sand (pl. 60, fig. 2). These granulations show no indication of being arranged in fields as they are in "*Cephalaspis schrencki*." The anterior and lateral margins are ornamented with coarser tubercles.

Dorsal features (pl. 60, fig. 6; text fig. 2).—The nasal fossa is large and relatively deep, with the wide foramen lying partly on the anterior wall, much as in *Trematas pis schmidti* and *Trematas pis milleri* (3). The fossa lies farther back than in *Trematas pis*, being partly between the anterior parts of the orbits, as in cephalaspids. Nothing is known as to the deeper structures in this region, but one would surmise that the canal joining the nasal aperture with the hypophysial fossa was short as in cephalaspids.

The orbits are about 3.5 mm long by 2.75 mm wide. They are about 7 mm behind the rostral border of the shield, thus only about one-fourth of the way back on the shield. In this they are more like *Oeselaspis* and *Dartmuthia* than like cephalaspids.

The dorsal field is situated close behind the pineal, its anterior end being between the posterior ends of the orbits. The field

is about 6 mm long and 2 mm wide. The lateral fields are single, extending from slightly anterolateral to the orbits, about 6 mm from the anterior margin, back about 2 mm posterior to the supratemporal line of the sensory canal system, about 10 mm anterior to the cornua. They are about 14 mm long and 2 mm wide at their widest part, near the anterior end. They show no posteromedian angle. No trace of nerve channels to the fields has been observed.

Sensory canal system (*text figs. 2, 3*).—In a rough sketch found among the notes left by Dr. Patten, most of the lines of the sensory canal system available on the specimens of *Rotsiküllaspis* are indicated, although he had not finished the sketch or attempted homologizing the lines. The *infraorbital* is similar in its course to that of *Trematas pis*, starting just posterolateral to the orbit, curving outward and forward to about opposite the nasal region, then inward and forward to near the mid-line. It does not extend out to the lateral field. So far as I can observe this line was a continuous groove rather than a series of dashes such as is found on *Trematas pis*. As in *Trematas pis*, a short line runs from the posterior end of the infraorbital back to the level of the supratemporal line. This I have termed the *postorbital* (3). The *main lateral line* is represented by a series of grooves from the supratemporal back to the posterior margin of the shield.

Two transverse lines, a short line on each side at the lateral portion of the anterior margin just anterior to the lateral field, apparently correspond to the *anterior marginal line* of trematas pids and the *supratemporal*. In trematas pids and some cephalaspids this latter line consists of three grooves or short series of grooves. In the present species I have found two grooves which seem to correspond to the two inner ones of trematas pids. Specimen T. 134 has a faint marking directed laterally from near the margin of the dorsal field in nearly the same location as the *anterior transverse* line of *Trematas pis*.

In *Trematas pis* certain lines have been found on the venter (3, 4). The only lines on the ventral aspect of *Rotsiküllaspis* found thus far are short grooves on two of the anterior plates over the oralobranchial chamber, plates which seem to correspond to members of the series which I termed the *posterolaterals* in *Trematas pis*. They are farther forward in this series than are those in *Trematas pis* on which sensory canals were found.

Oralobranchial chamber (*pl. 60, figs. 1, 4, 5; text fig. 3*).—The oralobranchial chamber has roughly the same form as in Trematas pidae. It has an angular process at the anterior end of its roof similar to that in cephalaspids and trematas pids, an angular process which Dr. Patten termed in his sketches an "ethmoidal cushion." At least nine and probably ten gill apertures were present on each side, seven along the posterior margin of the chamber, the other two or three along its lateral border. The posterior margin of the chamber has a median angular process as in *Trematas pis* but of different form and smaller size. It has a rather steep slope forward and medially from the median gill aperture of each side, extending about half-way to the mid-line. Then the edge slants inward and back. The whole edge of the process has the form of a letter M with its base spread so that the vertical lines slope at an angle of about forty degrees to the horizontal.

The diagonal rows of gill apertures are more nearly transverse than in *Trematas pis*. According to Rohon's description and to a text-figure (1) the gill apertures were enclosed within the solid part of the shield rather than notching its margins as they do in trematas pids. This statement was based on study of specimen 257/566, Paleontological Museum, Academy of Sciences, St. Petersburg (now at Moscow). Examination of the counterpart of this specimen and comparison with other specimens in the Patten collection indicate that Rohon interpreted notches in the posterior wall of the postbranchial ridge (3) as the branchial apertures, whereas the anterior wall of this ridge,

not available in his specimen, has the notches of the branchial apertures. This is well shown in specimens of the Patten collection (pl. 60, figs. 1, 4). In specimen T. 283, of which both part and counterpart are available, a number of the plates over the oralobranchial chamber are preserved, the median branchial plate showing, somewhat obscurely, a series of notches matching some of those in the posterior margin of the chamber, as they do in *Trematapis*.

The oralobranchial plates are fairly large, resembling those of trematapids and *Dartmuthia*. Unfortunately they are somewhat jumbled and distorted in the one specimen in which they are available (pl. 60, fig. 1), so that reconstruction of certain portions is very uncertain. The number must have been about twenty on each side. There are at least three diagonal rows of plates corresponding to the *branchial*, *postlateral*, and *anterolateral* series of trematapids (3). Distortion makes the middle portion obscure. Apparently a single elongated unpaired element replaced the paired *postmedians* and *anteromedians* of *Trematapis*. The posterior margin of this narrow plate is angular and fits the notch in the center of the median process of the posterior margin of the chamber. In the specimen a plate about the size of the fourth branchial lies in the mid-lateral region, partly covered over by a smaller roughly oval plate. What I take to be the corresponding plate of the other side is also partly concealed by another plate and also by being in part pushed beneath other elements. The oral part of the armor thus appears to differ from that found in *Trematapis* and *Dartmuthia* but cannot be reconstructed from the one specimen available. Text figure 3 is an attempted reconstruction of the plates whose positions can be made out with fair accuracy, and in this I have tried to indicate the jumbled plates of the oral region. Dr. Patten had worked out a reconstruction of these plates which does not differ essentially from mine save that the posterior border of the chamber has been worked out somewhat more than it had been when he drew his figure.

Post-shield region.—A few fragments which I take to have been lateral scutes of the region posterior to the shield have a similar ornamentation to that found on the shield. They appear to have similar form to corresponding plates in other Osteostraci. Specimen T. 577 (pl. 60, fig. 3) shows the caudal fin, which is normally heterocercal as in cephalaspids, and also some rows of scutes immediately anterior to the fin. These scutes are transversely elongated as in other Osteostraci. A double row of prominent tubercles occurs along the mid-lateral line, suggestive of the row of scales along the sides of *Acipenser*.

Skeletal structure.—The shield, as previously pointed out, is very thin. Its inner aspect is smooth, with something of the "warp and woof" effect of the same layer in *Trematapis*, but in many places showing the bases of tubercles. The superficial layer carries the granular ornamentation, with larger denticles along the margin of the shield. The granular elements are not arranged in any pattern.

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ORBITOIDS FROM THE CRESCENT FORMATION (EOCENE) OF WASHINGTON

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ABSTRACT

Discocyclina perpusilla subsp. *psila* Woodring and *Aktinocyclina aster* Woodring are recorded from the Crescent formation. As a lower middle Eocene age is assigned to these orbitoids, they represent the oldest marine Tertiary fauna of Washington. The geographic range of these genera on the Pacific Coast is extended northward.

The discovery of *Discocyclina* and *Aktinocyclina* in the Crescent formation along the northern margin of the Olympic Peninsula is valued for its bearing on correlation with other Eocene localities on the Pacific Coast and, also, for its record of a more northerly distribution of these genera in the Eocene of western North America.

Dr. C. E. Weaver (12a, 13) has mapped and described the occurrence at Port Crescent of Eocene basaltic lavas with interbedded sandstones, shales, agglomerates and water-laid tuffs. The Foraminifera discussed in this article occur near Observatory Point three and one-half miles east of Crescent Bay. Midway along the east side of this point (SE$\frac{1}{4}$, sec. 24, T. 31 N., R. 8 W.) are fossiliferous stratified black tuffs interbedded with coarse basaltic agglomerates. The dip is quite steep to the southwest. The tuffs are composed of roughly sorted angular basaltic fragments ranging from fine ash to lapilli several inches in diameter. Less than 200 feet north of the orbitoid-bearing layer, the underlying flows of the Metchosin volcanics outcrop. It is believed that these strata are equivalent to the basal portion of the Crescent formation as exposed near Tongue Point on Crescent Bay, which lie approximately eight hundred feet below the Eocene-Oligocene contact in the north limb of a syncline.

The author is indebted to Mr. Wyatt Durham for the original material collected from this locality and to Dr. H. G. Schenck, Dr. B. L. Clark and Dr. F. E. Turner for the loan of material for comparison from California and Oregon. Dr. C. E. Weaver, Dr. C. W. Merriam and Dr. W. P. Woodring have offered kindly criticism and advice.

The foraminiferal fauna is noteworthy for the occurrence of the orbitoids *Discocyclina perpusilla psila* Woodring and *Aktinocyclina aster* Woodring. Species of the following genera of smaller Foraminifera are also present: *Amphistegina*, *Anomalina*, *Certobulimina*, *Cibicides*, *Discorbis*, *Lamarkina* n. sp., *Gaudryina*, *Dentalina* cf. *D. substrigata* (Stache), *Quinqueloculina*, *Marginulina* cf. *M. nudicostata* (Cushman and Hanna).

Heretofore, *Discocyclina* has not been reported from western North America farther north than central Oregon (6). The present record extends the range of *Discocyclina* and *Aktinocyclina* to the northwest corner of the United States at Latitude 48° 10′ N. and is further proof of the wide extent of warm-water faunal assemblages during middle Eocene time.

The correlation of these Crescent strata with certain orbitoid-bearing limestones (Sierra Blanca) of Santa Barbara County, California, seems quite definite since both of these species are found in the latter beds. Further, a species of *Amphistegina* is associated with the orbitoids in both areas and several other small Foraminifera are possibly identical. It is unfortunate that the relation of the Sierra

Blanca limestone to the Eocene molluscan faunas of California is not very evident, but Keenan (2a) concluded that the age of this limestone was "either upper Meganos or lower Domengine." Recently, Reed and Hollister (7) referred the Sierra Blanca limestone to the upper middle Eocene, which is a younger horizon than the following evidence would indicate.

The *Discocyclina* associated with an *Aktinocyclina* figured by Keenan (2b) from an orbitoidal limestone on the south side of Mt. Diablo, Calif. appears to be very similar to *D. perpusilla* subsp. *psila*. Dr. C. W. Merriam (4) has identified *Turritella merriami* Dickerson from beds equivalent to those overlying this orbitoidal limestone and concludes that they are referable to the Capay (5) stage of the Eocene.

Specimens of an immature *Discocyclina* are found in Division E of the type Meganos on the northeast side of Mt. Diablo. These compare closely to *D. perpusilla* subsp. *psila*, giving further evidence of the stratigraphic position of this form. From a study of the microfauna, the author is convinced that Division E is referable to the Capay horizon, its fauna being similar to that found in the Vacaville shale and in the marine Eocene of Marysville Buttes.

As previously suggested (8) *Orbitolites oregonensis* Palmer is a synonym of *D. clarki* (Cushman). An examination of material collected by Dr. F. E. Turner indicates that *D. clarki* occurs in the upper portion of the Umpqua and in the Tyee formations of western Oregon. But *D. perpusilla* subsp. *psila* is found at two localities in the lower part of the Umpqua formation west of Roseburg and is not associated with *D. clarki*. At one of these places *Aktinocyclina aster* is also abundant. On the basis of molluscan evidence, the Umpqua formation of Oregon is correlated by Turner (9) with the *Turritella merriami-T. andersoni* fauna (Capay) of Middle California, while the Tyee is younger middle Eocene and equivalent to the Domengine.

The correlation of a megafauna from the uppermost beds at Port Crescent with that of the type Domengine is suggested by Vokes (11). The fact that the orbitoid fauna is found in considerably lower beds may explain the present author's reference to an older stage.

The previous observations and the Oregon occurrence, especially, would appear to indicate that the association of *D. perpusilla* subsp. *psila* and *Aktinocyclina aster* is indicative of a lower middle Eocene age. Furthermore, it is quite possible that *D. clarki* occurs in slightly younger deposits than the forms just mentioned.

There is no doubt that the beds from which the orbitoids were collected are of the same general sequence as those at Port Crescent. *Glycymeris crescentensis*, *Venericardia crescentensis*, *Solariella crescentensis*, *Eratopsis crescentensis*, *Galeodea tuberculata* var. *crescentensis*, *Ficopsis remondii* var. *crescentensis* and *Harpa crescentensis* occur at both localities. Weaver has at various times referred to the basaltic sequences on the northern margin of the Olympic Peninsula as equivalent to the Tejon of California, presumably meaning that they were younger Eocene than the Martinez. This is of course true since "Tejon" was used in an unrestricted sense, but the presence of the Foraminifera referred to in this paper date these marine tuffs as lower middle Eocene and equivalent in part to the deposits of the Capay stage of California and Oregon. These volcanics are older than those in the vicinity of Seattle (3) and in the Cowlitz River area of southwestern Washington (12b) where they are associated with later Eocene (Cowlitz) faunas. Thus, the agglomerates, tuffs, and associated sediments fringing the northern and northeastern margin of the Olympic Mts. and equivalent in age to the Crescent beds are to be regarded as the oldest marine Tertiary reported from Washington.

NOTES ON THE ORBITOIDS

DISCOCYCLINA PERPUSILLA Vaughan subsp. PSILA Woodring
Plate 61, figures 8–11

Discocyclina psila WOODRING, *1930*, San Diego Soc. Nat. Hist. Trans., vol. 6, pp. 148–151, pl. 14, figs. 2, 4–6, pl. 15, fig. 17.

A dozen specimens of a thin flat finely granulose *Discocyclina* have been compared with topotypes of *D. psila* and show close agreement of characters. The diameter varies from 3.2 to 4.2 mm and the greatest thickness from 0.4 to 0.55 mm. Diameters of the embryonic chambers and dimensions of the equatorial chambers correspond to Woodring's description of *D. psila* from the Sierra Blanca limestone in Santa Barbara County, California.

The larger embryonic apparatus and the greater average size of *D. perpusilla* subsp. *psila* appear to separate it from the typical *D. perpusilla* Vaughan (10a), but other characters are so similar that no more than a subspecific difference is indicated. *D. cloptoni* Vaughan (10b) is larger, has a broader and often peculiar embryonic apparatus, and the median chambers are more regular with a proportionately greater tangential diameter. The embryonic apparatus of *D. clarki* Cushman (1) is very similar to *D. perpusilla* subsp. *psila* except that the primordial chamber is often less enveloped by the circumambient chamber. Externally, *D. clarki* shows consistently larger papillae, usually has a slight central boss and a greater average diameter.

AKTINOCYCLINA ASTER Woodring
Plate 61, figures 1–7

Actinocyclina aster WOODRING, *1930*, San Diego Soc. Nat. Hist. Trans., vol. 6, pp. 152–155, pl. 14, figs. 3–6, pl. 16, pl. 17.

Abundant specimens of a stellate orbitoid are believed to fall within the variation of *A. aster* from the type locality. On a small minority of specimens the central boss is broader and thicker than on the topotypes of *A. aster*, however. A maximum diameter of 2.1 mm and a thickness of 1.75 mm is attained in Port Crescent specimens, but there is a complete gradation down to specimens showing almost no mamelon. The papillae vary in size from exceedingly fine granules extending over the entire surface, through moderately small papillae only on the mamelon and rays, to a closely papillate surface over the entire specimen with individual pustules on the central boss reaching 120 μ in diameter. The specimens with only a granular surface were found to be those with the least suggestion of a mamelon and with low broad rays. Measurements of the internal characters are in agreement with topotype material except that the thickness of the walls of the median chambers along

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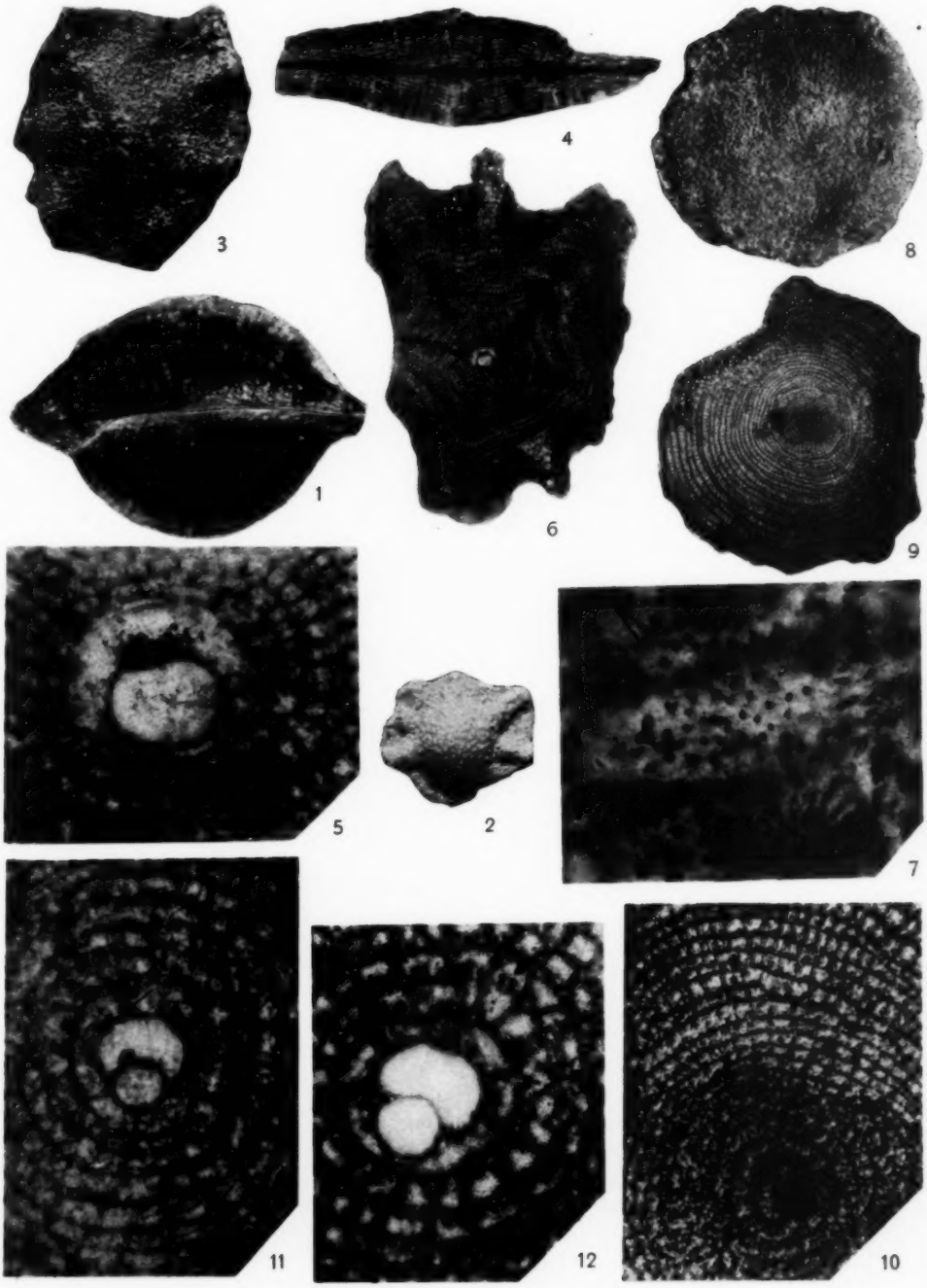
EXPLANATION OF PLATE 61

FIGS. *1–7—Aktinocyclina aster* Woodring, middle Eocene, Olympic Peninsula, Washington. *1*, Vertical section of extreme variant (var. A) with large central boss, ×20. *2*, Specimen (var. A) with large central boss and coarse papillae, ×5.6. *3*, Extreme variant (var. B) showing low, broad rays, finely granular surface, and only a slight central swelling, ×14.4. *4*, Vertical section of the typical form ×20. *5*, Embryonic apparatus of specimen shown in fig. 6, ×120. *6*, Horizontal section, ×16. *7*, Pores on roof of equatorial chambers, ×440. (p. 496)

8–11—Discocyclina perpusilla Vaughan subsp. *psila* Woodring, middle Eocene. *8*, Olympic Peninsula, Washington. The finely granular surface of the exterior and the absence of a mamelon are in contrast to *D. clarki*. ×12. *9*, Horizontal section, ×12, Olympic Peninsula, Washington. *10*, Horizontal section, ×52, Olympic Peninsula, Washington. *11*, Horizontal section through embryonic apparatus, ×88, lower Umpqua formation, Univ. of California locality A835, Roseburg-Coos Bay highway, Oregon. (p. 496)

12—Discocyclina clarki (Cushman), middle Eocene, Univ. of California locality 1817, north of Coalinga, California. Embryonic apparatus, ×88. (p. 496)



Berthiaume, Eocene Foraminifera

UNIV. OF MICH.

the rays exceeded the figures given by Woodring by $5 \pm \mu$.

This species is apparently quite variable but, since there is an abundance of intergrading forms in a single bed, with the intermediate type most numerous, it would not be appropriate to designate even the more distinct groups by new names. The use of letters, however, for the more marked varieties will be advantageous for brevity and clarity in subsequent references.

Variety A (figs. 1, 2): Central boss much broader and thicker than the average width of 1.2 mm and thickness of 1.0 mm. Associated with this are papillae with a diameter usually of 70 to 120 μ extending over much of the surface.

Variety B (fig. 3): Quite thin ($0.5 \pm$ mm); surface finely granulose with 90 per cent or more of the granules less than 60 μ in diameter; rays broad and less pronounced.

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PENNSYLVANIAN SPONGES OF NORTH-CENTRAL TEXAS

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ABSTRACT

A new genus, *Fissispongia*, is established. It is based on the new species *F. jacksboroensis* and includes the new species *F. spinosa* and the species previously described as *Maeandrostia tortacloaca* R. H. King. Additional details of the structure of *Wewokella solida* Girty are described.

Because of their comparative simplicity of form, sponges are not subject to the rapid or extreme variations of more highly specialized organisms and therefore survive for long periods of time without apparent modification. Because of this inability to change with changing conditionsof environment their geographic distribution is limited to the areas wherein conditions are favorable for their growth. Usually such conditions are not favorable for the preservation of the remains as fossils. Furthermore, in outcrops where sponges are found they are seldom associated with a rich and varied fauna of more highly specialized forms sought by collectors, and therefore go unnoticed. Hence, it is not surprising that they have been neglected by stratigraphers and paleontologists with few exceptions.

The writer has previously (1) expressed the opinion, based entirely on the study of collections in the laboratory, that sponges might be useful in stratigraphic correlation. After actual study of these animals in the field he has greatly modified but not entirely abandoned this belief. The sponges were found to be proportionately much more numerous in the field than in the laboratory collections, probably because paleontologists had not sought localities having an almost exclusive sponge fauna and had not collected sponges where other forms were to be found. There is the further possibility that to collectors unfamiliar with these organisms they had the appearance of fucoids, concretions, or other seemingly worthless material. Whatever the reason may be, the discrepancy in the relative numbers of sponges in the field and in the collections available to the writer exists, and the scarcity of publications dealing with sponges indicates similar slighting in other collections.

These organisms were found to be not only more numerous than previously supposed but also more widely distributed, both geographically and stratigraphically. They were found in some member of every formation of the Strawn and Canyon groups except the Garner (2), and also in the Graham formation of the Cisco group (fig. 14). Specimens of *Wewokella solida* Girty were found in formations as young as lower Permian. The range of nearly every species was extended and two new species and one not previously noted from Texas were found. Specimens presenting additional evidence bearing on the generic position of *Wewokella solida* were also discovered. Many of the species occurring in Texas have already been described by Girty (3) and later, with some additional forms, by the writer (1*a*) and there is nothing to be gained by a repetition of those descriptions.

The reader will note that two very similar generic names, *Girtyocoelia* and *Girtycoelia*, have been used herein. In 1909, soon after the appearance of Girty's paper, Cossmann (4) observed that the name *Heterocoelia* was preoccupied, having been used by Dahlbom (5) in 1854. He therefore offered *Girtyocoelia* as a substitute, and this name is valid.

Hence, species previously referred to *Heterocoelia* are now referred to *Girtyocoelia*. Unfortunately, the writer was unaware of this change when he established the genus *Girtycoelia* in 1933 to include *Steinmannia benjamini* Girty and *Girtycoelia typica* R. H. King. There are, therefore, two genera with very similar but not identical names occurring together in some formations. As both names have been published and since they differ by a syllable both will stand (6). Had Cossmann, in accordance with the Code of Ethics set forth in the Rules of Nomenclature, requested Dr. Girty to rename his genus the writer would have been informed of the change, and the regrettable similarity would have been avoided. This is not offered as an excuse, but as an argument in favor of strict observance of the Code for other than ethical reasons.

In the writer's previous paper on the sponges (1*c*) Locality 3 was stated to be the Parr ranch south of Chico, Graford formation, collector Böse. The discovery of some of Böse's notes resulted in a correction of this locality. The Parr ranch was west by north of Chico and the specimens were collected above the Ranger limestone, in the Caddo Creek formation. In the accompanying distribution table (fig. 14) these specimens have been correctly located.

SYSTEMATIC DESCRIPTIONS

Subclass CALCISPONGIAE
Genus FISSISPONGIA King, n. gen.

The three species, *Fissispongia jacksboroensis*, n. sp., *F. tortacloaca* (R. H. King), and *F. spinosa*, n. sp., constitute a compact phylogenetic group. They are long cylindrical bent or branching forms. They have a thin-walled central cloaca, which divides long before the branches become visible external features. The result is that through long portions of the body there are two or even more parallel cloacae. This structure was misinterpreted by the writer in his description (1*b*) of *F. tortacloaca* (R. H. King). At that time no specimen had been observed in which the actual walls of both cloacae were discernible, and the sponge was thought to have a dense outer wall with a less dense, more easily eroded inner portion which contained so little organic matter that it appeared hollow (filled) in sections. The species was referred to *Maeandrostia*, though certain differences were noted that might be sufficient to necessitate its removal to another genus. In the present paper it is being included in the new genus *Fissispongia*, which differs from *Maeandrostia* not only in the premature fission of the cloaca but also in the nature of its dermal layer. In the genus *Maeandrostia* the dermal layer is perforated by scattered ostia but not by pores. In *Fissispongia* it is minutely pitted by what appear to be pores and is raised into scattered spinose projections penetrated by one or more canals. On the specimens observed only a very few of these processes are unbroken, but these few are not perforated except by pores. If this were true of all the projections originally, which cannot be stated definitely but seems probable, the dermal layer is perforated by pores but not by ostia. The function of the spinose processes is not clear. The sponge wall is composed of irregular vermiform chambers separated by apparently structureless partitions as in *Maeandrostia*.

Genotype.—Fissispongia jacksboroensis King, n. sp.

FISSISPONGIA JACKSBOROENSIS
King, n. sp.
Figures 6–9

Fissispongia jacksboroensis is the largest species referred to this genus. The average diameter is about 6 or 7 mm, and the largest specimen observed has a diameter of 9 mm. Specimens only 4 mm in diameter are comparatively small. The longest fragment found measured 42 mm in length, and the diameter was uniform except where branches diverged. Speci-

mens cannot be oriented by size alone, as the fragments found are too short to show any appreciable difference in diameter between the two ends.

The dermal layer is smooth except for the small pores and the projections mentioned in the generic description as characterizing the genus, but on some specimens it is gathered in baggy folds. All specimens are more or less constricted at irregular intervals, but the constrictions are broad and shallow. The spinose processes are small but long, and may be arranged roughly in rows around the specimen but not along it.

This species differs from *F. tortacloaca* (R. H. King) in the greater length and number of its spinose processes as well as in its greater size. From *F. spinosa* King, n. sp. it differs in that it is much larger but has smaller spines.

F. jacksboroensis occurs in the Brad, Caddo Creek, and Graham formations but is especially abundant in the Jacksboro limestone member of the Caddo Creek formation.

Syntypes.—Bureau of Economic Geology no. K-1467, University of Michigan Museum of Paleontology nos. 16293, 16294, and 16295, and Illinois Geological Survey no. 3415, all specimens from the Jacksboro limestone in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, which is the type locality.

FISSISPONGIA SPINOSA
King, n. sp.
Figures 1–5

Fissispongia spinosa has thus far been collected only in small straight or bent fragments, rarely branching, although it is almost certainly a branching form. The largest specimens are about 5 mm in diameter but the average size is about 3.5 mm. The longest fragment found measured only 25 mm in length.

The dermal layer is somewhat wrinkled and the spinose processes are large and strong, extending as much as a millimeter from the surface, so that the individuals have a rough appearance. Slight constrictions are not rare, and these add to the general effect of roughness.

A single fragment (fig. 3) retains what appears to be the surface of attachment, but part has been broken away. The remainder is a small horizontal arc, one end of which is reflected over the center and then curves upward to become the main sponge body. At the point where the break occurred the specimen is about half the diameter of the body above the base, the expansion to full size being rapid. This individual does not increase appreciably in size above the base, where it measures about 3 mm., so it is presumable that fragments as much as 4 or 5 mm in diameter must come from very long specimens, although none have been found.

This species may be distinguished from *F. jacksboroensis* King, n. sp., by its smaller size, its larger and stronger spinose processes, and the rarity of branches. From *F. tortacloaca* (R. H. King) it differs in that it is more spinose and rough in appearance, the spinose processes being larger as well as more numerous than in that species.

F. spinosa has been found at only one locality, which is in the Millsap Lake formation. It is quite abundant at that place.

Syntypes.—Bureau of Economic Geology no. K-1166, from the shale below the Kickapoo Falls limestone member of the Millsap Lake formation in a creek bank 0.65 mile south and east of Kickapoo Falls, Hood County, Texas.

Genus AMBLYSIPHONELLA
Steinmann, 1882

AMBLYSIPHONELLA PROSSERI Clarke
Figure 10

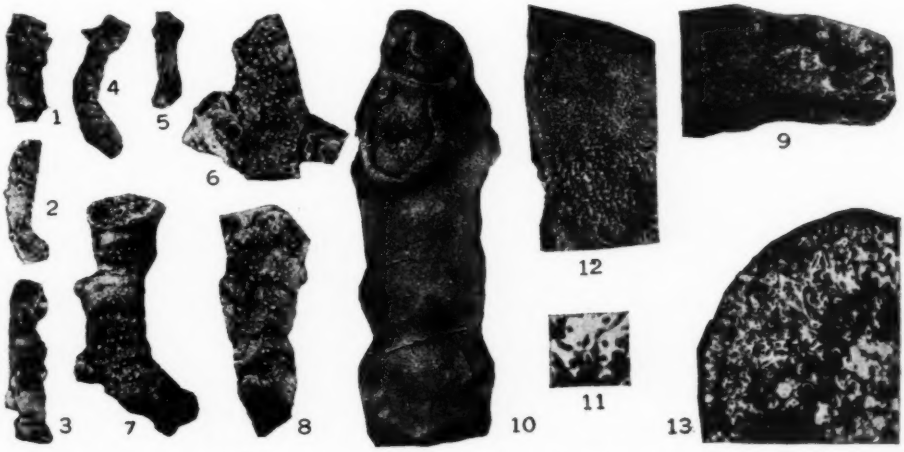
Amblysiphonella prosseri CLARKE, *1897*, Am. Geologist, vol. 20, pp. 387–392, pl. 23, figs. 1–9.—BEEDE, *1900*, Kansas Geol. Survey, vol. 6, pt. 2, pp. 14–16, pl. 1, figs. 2–2e (not 2f), pl. 2, fig. 6.—WOODRUFF, *1906*, Nebraska Geol. Survey, vol. 2, pt. 2, p. 258, pl. 4, fig. B.

Specimens of this species are straight or bent cylindrical bodies constricted at short intervals and minutely perforated.

Internal characters include a continuous central cloaca and a series of ring-shaped chambers, the constrictions coinciding with the partitions between chambers.

The chambers are circular in cross section and arched on the upper side. As each segment is built on the preceding one, using its upper surface for a floor, the longitudinal section shows an upper and a lower arch of slight curvature connected by the slightly bulged outer walls. The outer walls and the partitions are about 0.65 mm thick and perforated by minute pores; the pores in the cloacal wall are slightly larger than the others. The chambers contain varying but large amounts of vesicular material, which has a thickness of about 0.1 mm.

The cloaca is about one-third the diameter of the entire body. Its upper termination is a simple "osculum," actually an excretory aperture. The lower termination is unknown. Its walls are slightly constricted at intervals, the constrictions corresponding to those of the external surface. The cloaca contains no vesicular material as its function was that of an excretory duct. The thickness of its wall is about 0.2 mm.



FIGS. *1–5—Fissispongia spinosa* King, n. sp., ×1. Five individuals from the Millsap Lake formation in the creek banks 0.65 mile southeast of Kickapoo Falls, Hood County, Texas. K-1166. (p. 500)

6–9—Fissispongia jacksboroensis King, n. sp. *6–8*, Three individuals from a shale parting in the Jacksboro limestone in the Rock Island Railroad cut 3.7 miles southeast of Jacksboro, Jack County, Texas, ×1. K-1467; *9*, longitudinal section of another individual from the same locality showing fission of the cloaca, ×3, K-1467. (p. 499)

10—Amblysiphonella prosseri Clarke, ×1. A specimen from the Graham formation on the bluff south of the road 2 miles east of Fife, McCulloch County, Texas, K-1106. (p. 500)

11–13—Wewokella solida Girty. *11*, Section showing octact spicule, ×6; *12*, specimen from the Mineral Wells formation 2 miles west of Salesville, Palo Pinto County, Texas, ×1. The dermal layer has been removed from the lower part of the specimen by erosion. The section of *11* and *13* was cut from the upper end of this specimen, K-1378. *13*, Transverse section showing canals, ×3. (p. 502)

Beede (7) confused this species with the form that Girty later described as *Heterocoelia beedei* (now *Girtyocoelia*). The latter, however, is composed of cells complete in themselves and not built one upon another with a common wall. Furthermore, *Girtyocoelia* is an imperforate body with large ostia, whereas *Amblysiphonella*, as previously stated, has only minute perforations. Externally *Amblysiphonella prosseri* Clarke more closely re-

sembles species of the genus *Girtycoelia*, but this form also may be distinguished by its larger pores. The essential difference, however, is the absence of a cloaca in *Girtycoelia*, which feature is discernible on most specimens of *Amblysiphonella* without sectioning.

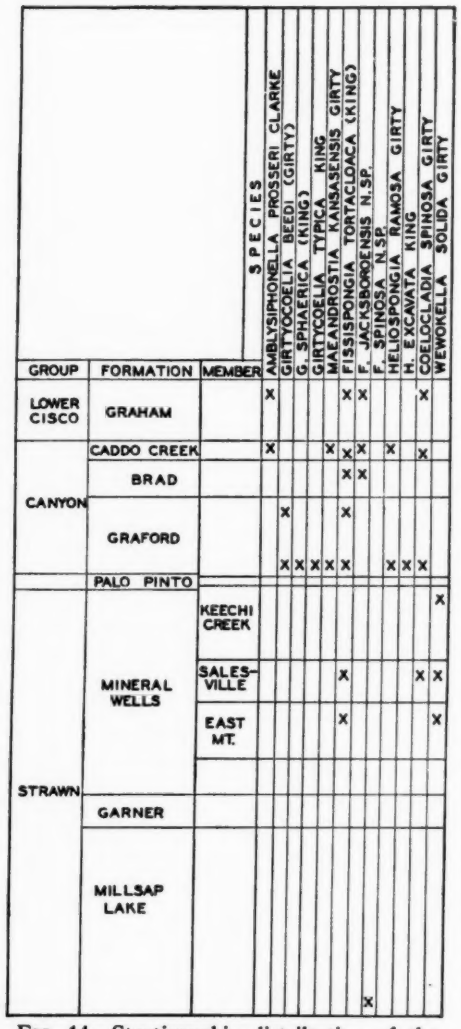


FIG. 14—Stratigraphic distribution of the sponges of north-central Texas.

Hypotypes.—Bureau of Economic Geology no. K-1106, from the Gunsight limestone member of the Graham formation in a bluff 2 miles east of Fife, McCulloch County, Texas.

Subclass SILICISPONGIAE
Suborder OCTACTINELLIDAE ?
Hinde, 1887
Genus WEWOKELLA Girty, 1915
Figures 11–13

In the collections from the upper Mineral Wells formation of north-central Texas there are several specimens of this genus apparently conspecific with the genotype, *Wewokella solida* Girty, from the Wewoka formation of Oklahoma. Their stratigraphic occurrence is slightly higher than that of the Oklahoma specimens, as indicated by the absence of specimens of the brachiopod genus *Mesolobus*, which is abundantly represented in the Wewoka and the middle Mineral Wells formations but abruptly becomes extinct. The original silica of the sponges has been almost completely replaced with barite, and the interstices have been filled with dark but transparent calcite. A study of this exceptional material indicates that the original description was incorrect in several particulars. Most of the discrepancies are undoubtedly due to the fragmentary character of the type material.

The genus was based on two small poorly preserved fragments. One of these was broken longitudinally and showed a central cavity, which was interpreted as a cloaca. The Texas specimens examined are solid except in the terminal portion, the cloaca having been progressively filled as the sponge body was extended. From his figures and description it is not possible to determine whether Girty's specimen was an unfilled fragment from the extremity of an individual or one from which the filled portion had been removed by weathering. Whichever it was, its appearance gave rise to a misconception of the true nature of the animal.

The weathered exterior of Girty's specimens showed irregular ridges trending generally longitudinally, which he interpreted as large greatly modified tetract skeletal elements. It seems more prob-

able, however, that these features are thick-walled tubes constituting a canal system. In sections they are seen to branch freely to form a system that is arranged in general axially and radially. The internal diameter of the tubes is about one-third the external diameter, and the tubes branch at various points. Although spicules with very large axial canals are known (e.g., *Carterella* Zittel), all the axial canals of spicules of most sponges diverge from a single central point. Furthermore, what appear to be small circular ostia perforating the dermal layer open into these tubes. It is improbable that a skeletal spicule would extend through the dermal layer, but should it, the walls of the tube as well as the opening would be visible on the surface. The walls of the tubes appear to be fibrous.

In the description of the type species the statement that there are other much smaller tetraxons among the larger spicules apparently refers to the flesh spicules, which are, however, octacts when perfectly developed. In fairness to Dr. Girty it should be pointed out that the nature of the flesh spicules is apparent only if the material around them is transparent, as a section through a tetract does not differ greatly from a section through an octact. Only three rays of either type of spicule are cut by a plane unless by accident the cutting plane coincides with a plane of symmetry, in which section the octact would appear as a cross or as a six-rayed star.

The dermal layer, which was not preserved on the type specimens, is composed of small heteract spicules with large spherical nuclei. Each has three or more long, thin rays parallel to the surface of the sponge body and several outwardly directed rays, which are reduced to mere knobs. Apparently the spicules were anchored by a single large ray directed inward into the sponge body, but this could not be determined definitely.

The material with which the lower part of the cloaca was filled is now preserved as irregular blocks of crystalline barite. It was deposited by the sponge itself, because there are flesh spicules between the blocks, but its original form and method of deposition are unknown. Sections through this part cut through a few scattered tubes, but most of the tubes are concentrated in the thick walls of the body.

Because of the complex form of the spicules this genus is referred to the Silicispongiae, but a more precise classification is difficult. Its massive form is suggestive of the Lithistidae of Schmidt, and its canal system is similar to Zittel's type 5 of lithistid canal systems as redescribed by Hinde (8), but apparently there are no lithistid skeletal spicules, and the dermal and flesh spicules differ from those of the known Lithistidae. The fibrous walls of the tubes are similar to the walls of some of the Calcispongiae of Blainville, but the dermal and flesh spicules are more complex than those of known calcareous sponges. Because the spicules are the basis for classification it seems best to include *Wewokella* with the Octactinellidae of Hinde. This suborder is otherwise represented by the single genus *Astraeospongia* Roemer which occurs in the Silurian and Devonian systems. The genotype of that genus, *A. meniscus* (Roemer), is discoidal and the spicules have not yet developed the two rays perpendicular to the plane of the six-rayed star, which appear in the Devonian representatives of the genus. Topotype specimens of *A. meniscus* were sectioned to determine the canal system, but the body was completely silicified. The spicules of the genotype of *Astraeospongia* are much larger than those of *Wewokella*. The provisional classification of the latter with the Octactinellidae is not entirely satisfactory.

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JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 5, PP. 505–507, 8 TEXT FIGURES, SEPTEMBER, 1938

NEW SPECIES OF GASTROPODA FROM THE OLIGOCENE OF COLORADO

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ABSTRACT

Fossil gastropods from the Oligocene Antero formation of Park County, Colorado, prove to be new species of the genera *Valvata*, *Pseudosuccinea* and *Gonyodiscus*. These have interesting relationships with species in the earlier Tertiary and the living faunas.

These notes are descriptive of three new species of gastropods, representing, respectively, the genera *Valvata*, *Pseudosuccinea* and *Gonyodiscus*. The specimens are from the Oligocene of South Park, Park County, Colorado, and were submitted to the writer for study by Professor J. Harlan Johnson, of the Colorado School of Mines, who also supplied the notes on occurrence that accompany the descriptions. By agreement with Professor Johnson, the types are deposited in the United States National Museum.

The non-marine molluscan faunas of the North American mid-Tertiary are not satisfactorily known. Abundant material has been collected from the late Cretaceous and the Paleocene sediments, but these faunas differ in many ways from that living today. It is to the middle and late Tertiary that we must look for the origins of our modern fauna. For this reason the material here described is of special interest.

Family VALVATIDAE

Genus VALVATA Müller, 1774

VALVATA CRATERELLA
Russell, n. sp.
Text figures 1–3

Shell strongly bicarinate; spire concave, apex depressed below level of body whorl; dorsal carina prominent; ventral carina very prominent, closely circumscribing the umbilicus, which is narrow and deep; periphery of body whorl sharply rounded but not keeled. Height of holotype, 2.9 mm; maximum diameter, 5.0 mm.

Type.—A nearly complete shell, U. S. National Museum 497660.

Occurrence.—Oligocene lake beds of the Antero formation (1), SW ¼ sec. 1, T. 10 S., R. 75 W., Park County, Colorado.

Remarks.—This species resembles the modern *V. bicarinata* Lea in the presence of two carinae and a depressed spire. But in *V. craterella* these features are more pronounced, and the ventral carina closely circumscribes the margin of the umbilicus. Some varieties of *V. bicarinata* have a third, peripheral carina, but such a structure is not present in the specimens of *V. craterella* before me. Among fossil species there is some resemblance to *V. bicincta* Whiteaves (2), from the Paleocene, which is probably the same as *V. subparvula* Cossman (= *V. parvula* Meek and Hayden) although the identity cannot be determined. In any case, the spire of *V. bicincta* is only moderately depressed, and its carinae are distinct but not markedly prominent. Hence *V. craterella* differs from *V. bicincta* in much the same way that it does from *V. bicarinata*. *V. craterella* may be considered an aberrant member of the *V. bicincta*-*V. bicarinata* line.

Family LYMNAEIDAE

Genus PSEUDOSUCCINEA
Baker, 1908

PSEUDOSUCCINEA VENUSTA
Russell, n. sp.
Text figures 4, 5

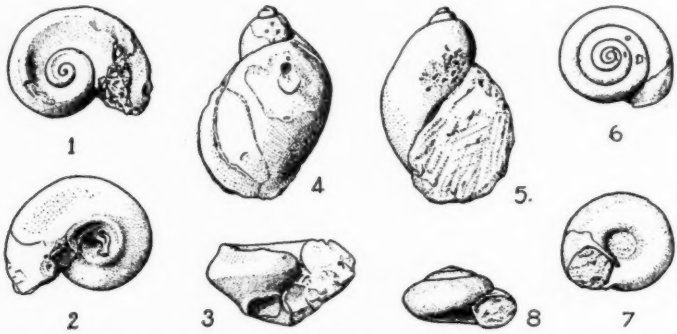
Shell rather large, relatively broad; volutions about 3½; length of spire less than half that of body whorl; body whorl

somewhat inflated; aperture broad, angular behind; a narrow umbilical chink apparently present; surface marked by irregular growth lines. Length of holotype, 12.8 mm; maximum width, 8.8 mm; length of aperture, about 8.6 mm.

Type.—Cast of the interior, U. S. National Museum 497658.

Occurrence.—Oligocene lake beds of the Antero formation, SW corner sec. 13, T.13 S., R. 76 W., Park County, Colorado.

It is possible that the fossils here described as *Pseudosuccinea venusta* are cospecific with *Lymnaea nebrascensis* Evans and Shumard (3), from the White River Oligocene of South Dakota. The rather indefinite diagnosis given for *L. nebrascensis* would not exclude the present specimens, but as no figures were ever published, and as the types are apparently lost, it seems the better procedure to describe the Colorado fossils as new, and to leave the question of relationship



FIGS. *1–3—Valvata craterella* Russell, n. sp. Apical, basal, and apertural views of holotype, ×4. (p. 505)

4, 5—Pseudosuccinea venusta Russell, n. sp. Dorsal and ventral views of holotype, ×2. (p. 505)

6–8—Gonyodiscus hendersoni Russell, n. sp. Apical, basal, and apertural views of holotype, ×2. (p. 506)

Remarks.—*P. venusta* is apparently close to the living *P. columella* (Say), from which it differs in having the shell somewhat larger and proportionately broader. *P. columella* has numerous revolving lines on the surface, but if these were present in *P. venusta* they have not been preserved in the fossils. These lines constitute one of the few shell characters that serve to distinguish *P. columella* from species of *Succinea*, a terrestrial genus. Hence it might appear that the fossils actually represent *Succinea*. The strongest argument against this view is the occurrence of the fossils in a lacustrine limestone associated with remains of algae and ostracods, from which association an aquatic environment may be deduced.

to *L. nebrascensis* until good topotypes of the latter are available.

Family ENDODONTIDAE

Genus GONYODISCUS Fitzinger, 1833

GONYODISCUS HENDERSONI Russell, n. sp.

Text figures 6–8

Shell rather large for the genus; volutions about 4; aperture with short, closely appressed inner lip, from which the margin expands above and below to the much longer outer lip; surface with regular but inconspicuous retractive costulae. Height of holotype (measured parallel to axis of spire), 4.4 mm; maximum diameter, 7.8 mm; maximum diameter of aperture, 3.5 mm.

Type.—Complete shell, U. S. National Museum 497659.

Occurrence.—Oligocene lake beds of the Antero formation, SE ¼ sec. 22, T. 10 S., R. 76 W., Park County, Colorado.

Remarks.—This species may be distinguished by its weak ornamentation and its abbreviated inner lip. The shell form may be compared with that of *G. ralstonensis* (Cockerell) (4) of the Eocene, and *G. shimekii* (Pilsbry) in the Recent and Pleistocene faunas.

The specific name is given in honor of Dr. Junius Henderson, who is well known for his studies of the fossil and Recent Mollusca of the western States.

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JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 5, PP. 508–510, 2 TEXT FIGURES, SEPTEMBER, 1938

A STOMATOPOD FROM THE MISSISSIPPIAN OF CENTRAL MONTANA

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ABSTRACT

A well-preserved stomatopod from the basal part of the Heath shale (Mississippian) of central Montana is described as *Squillites spinosus* gen. and sp. new. It belongs to the modern family Squillidae. Parts of the first and second antennae, the monodactylus maxillipede, and most of the appendages on the twentieth somite are preserved, as well as the abdomen, thorax, and carapace.

A well-preserved stomatopod was found in the basal part of the Heath shale[1] two miles south of Heath, Montana, along Spring Creek, on the north flank of the Big Snowy Mountains. It was obtained from a black fissile shale at or near the *Leiorhynchus carboniferus* zone. The remains consist of white to gray tissuelike material that represent the dorsal side of the animal. When the fissile shale was split, most of the tissue remained on one part of the rock and an imprint on the other. The state of preservation is very good, and many details of ornamentation and segmentation can be seen. A second specimen was also obtained from the same locality. It shows the same type of abdominal and thoracic features as well as ornamentation. The carapace was not preserved, but the specimen unquestionably belongs to the same species of animal as that described below.

One of the most common modern representatives of the Stomatopoda is *Squilla*, a genus including about 53 species, most of which live within the littoral zone in warm-temperate to tropical seas. All modern Stomatopoda belong to the family Squillidae, which includes six genera. Kemp (2, p. 17) considers *Squilla* the most primitive member of the family. Fossil Stomatopoda are uncommon, only a few having been described. All of the known fossil forms are Mesozoic or Cenozoic. Two fragmentary specimens from the Carboniferous have been described but have been considered by Kemp and others as of doubtful affinities. Their rarity may be partly explained by the fact that they prefer very clear and quiet water undisturbed by accumulating sediments.

I am indebted to Dr. H. J. Van Cleave, Professor of Invertebrate Zoology, University of Illinois, for aid in identification.

SYSTEMATIC DESCRIPTIONS

Series EUMALACOSTRACA Grobben
Division HOPOLOCARIDA Calman
Order STOMATOPODA Latreille
Family SQUILLIDAE? Latreille
Genus SQUILLITES Scott, n. gen.
Text figures 1, 2

This genus is erected to include those fossil stomatopods that possess a broad abdomen and thorax, thoracic somites not covered by carapace, and appendages well developed on penultimate somite.

Genotype: *Squillites spinosus* Scott, n. sp.

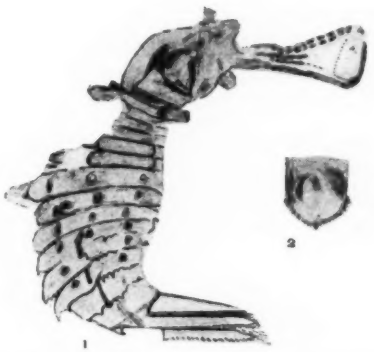
SQUILLITES SPINOSUS Scott, n. sp.

The abdomen is as broad as long; each abdominal somite marked by three prominent knobs, one median and two

[1] The Heath shale is part of part of what was formerly called Quadrant (Pennsylvanian). It is now known to be Mississippian in age and has been placed by the writer in the Big Snowy group.

laterals, each of which may have borne a small sharp spine. Tergal and epimeral carinae are absent. Posterolateral angle of each somite extends backward into a sharp tooth (development of tooth not certain on segments 19 and 20). The posterior margin of each abdominal somite was probably serrate, forming a series of small posteriorly directed spines. Imprints on the tergal portion of somites 20 to 16 appear to be impressions made by curved spines. Such imprints do not occur on the thoracic segments. Abdominal somites are approximately equal in width, posterior ones slightly broader.

The thoracic somites are almost equal to the abdominal segments in width, and though all of them are not well preserved they appear to have been as highly ornamented. Somites 14, 13, 12, 11, and 8 show that the thoracic segments were marked with three rows of knobs similar to those on the abdominal divisions. However, no evidence of a serrated posterior margin nor of the existence of spines on the tergal portion could be found. One of the most remarkable features about this stomatopod is the great length of the thorax and the uncovered condition of the thoracic segments. In most forms, both fossil and recent, only the posterior four thoracic somites are exposed; the remaining segments are covered by the carapace. In *Squillites spinosus* all 8 thoracic somites are exposed posterior to the carapace. In most Stomatopoda the abdomen makes up the greater part of the body length of the animal, but in this species the thorax and abdomen are of equal length. Furthermore, in most forms the thoracic somites are not as broad as those in the abdominal area, but in *S. spinosus* they are approximately equal in breadth. Considerable ambiguity exists concerning the history of modern Stomatopoda and the fossil record is very poor; therefore, little can be inferred about the biological significance of the thoracic features possessed by this Early Carboniferous species. This may be a primitive feature that will be found in most Paleozoic species, or it may be peculiar to *S. spinosus*. No reduction in size of the thoracic somites in this Carboniferous form has taken place. Mesozoic specimens described by Woodward (6) have only the posterior three segments exposed, whereas in *S. spinosus* all eight segments are posterior to the carapace.



FIGS. *1*, *2*—*Squillites spinosus* Scott, n. sp., sec. 23, T. 14 N., R. 19 E., 2 miles south of Heath, Montana; *1*, holotype, ×5; *2*, second antennae, ×20.

The carapace is relatively small, broadly pointed anteriorly, subquadrate posteriorly, and has a flat to gently rounded surface. Posterior edge of shield is sharply raised above anterior thoracic somite. Rostrum small and sharply rounded.

Some of the anterior appendages and those on somite number 20 are well preserved, but in general the abdominal and thoracic appendages are poorly preserved. The first antennae are relatively long, slender, and uniformly tapering organs composed of many short barlike divisions. They appear to be simple antennae with no flagellate divisions at the termini. The second antennae are represented by one faint impression. They are short subquadrate structures with the distal part broadly rounded. The rounded part is marked by a series of closely spaced and short bristlelike structures. Thirteen such bristles occur on

each side of a larger central spine. The surface is smooth with the exception of low rounded ridges on each side near the margin and posterior to the frilled anterior edge. The second antennae are very similar to those of modern Squillidae but are more quadrate in shape.

On the left side of the carapace is the imprint of a long broadly curved merus. It issues from under the posterior corner of the carapace and extends forward in a broad arch to a position anterior to the front of the shield. A similar but poorly preserved merus also occurs on the right side of the carapace. The anterior part of the raptorial claws is not well preserved. They are probably represented by the formless material anterior to the carapace. A few small imprints in this area probably represent spines of the dactylus.

Small abdominal appendages are characteristic of the Stomatopoda, and consequently are seldom well preserved in the few fossils known. They are so poorly preserved in the specimens from the Heath shale that nothing definite can be said concerning their character.

Uropods extend posteriorly from the end of the 20th somite. They are relatively long and taper gently to posterior spines. The surface is smooth, the outer edge is set with numerous small spines, and the posterior part with hairlike processes. The telson characteristics are uncertain.

Measurements: Thorax, 6.5 mm wide, 6 mm long; abdomen, 6.5 mm wide, 6 mm long; uropods, 6.5 mm long; first antennae, 7 to 10 mm long; second antennae, 0.8 mm wide, 0.9 mm long; carapace, 2.5 mm wide, 3 mm long.

Holotype.—University of Illinois no. X-1219.

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JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 5, PP. 511–513, SEPTEMBER, 1938

ONONDAGA PAINT-ORE FAUNA FROM PENNSYLVANIA

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ABSTRACT

The paint ore of the Onondaga group in the Lehigh Valley, Pennsylvania, has furnished a considerable fauna, of which several abbreviated and incomplete lists have been published. The collection in the Department of Geology of Lehigh University is here listed. The fauna is atypical in that there is a great paucity of mollusks and an unusually large number of species of trilobites.

The Onondaga group in Pennsylvania comprises the lowest part of the Middle Devonian. It rests unconformably (in disconformity) upon the Oriskany, of late Lower Devonian age, from which it is faunally quite distinct. The Onondaga group is succeeded by the Marcellus formation, lowest of the Hamilton group. The Onondaga and Marcellus are mutually transitional except for local "marginal" unconformities and are biologically closely related. The first writer to describe the Onondaga throughout Pennsylvania was E. M. Kindle (3). Nothing further appeared on the group until Willard's paper of 1936 (5). With slight modifications, his statements made at that time are accepted, but it should be noted that his suggestion of classing the Onondaga as part of the Hamilton group was abandoned shortly after the appearance of the Onondaga paper (6,7). The Onondaga is treated as a group rather than a formation.

The Onondaga enters Pennsylvania in the Delaware Valley and continues to the Susquehanna in a nearly straight band. It zigzags through the central counties and passes over into Maryland from the south-central border. Its thickness changes considerably. A maximum of over 400 feet is encountered in the extreme east, with a minimum of perhaps 10 feet in northern Lebanon County, west of which the sections usually are between 150 and 200 feet thick. In central Pennsylvania the Onondaga consists of limy shale at the base passing upward into limestone without chert. In the Lehigh Valley the Esopus shale is overlain disconformably by the paint ore, which passes upward into non-cherty Onondaga limestone and thence into cherty limestone. In Monroe County the Esopus shale passes upward into cherty Onondaga limestone. We are here concerned only with the paint ore, which is interesting because of its exceptional fauna.

The paint ore is found in the Lehigh Valley near Palmerton. It has been mined for the better part of a century, and its economic aspects have been described (2, 3, 4). Its position in the section, its intergradation with the overlying limestone, and its faunal characteristics indicate that it is apparently a direct correlative of the upper part of the basal Onondaga limy shale of central Pennsylvania and of the upper part of the Esopus of Monroe County.

The collection of fossils here discussed was made by Whitcomb and other members of the geological faculty and student body at Lehigh University, where it is preserved. Like other Onondaga faunas, the paint-ore fauna contains many brachiopods, but some of its common species are rare or absent elsewhere in

Pennsylvania, and species plentiful elsewhere are rare in it. Mollusca are very rare. A single gastropod, *Diaphorostoma lineatum*, has been identified, but not a pelecypod nor cephalopod was found in the paint ore, though all these classes are common in other members of the Onondaga group in the State. The trilobites are both numerous and varied. These organisms are often plentiful in the more limy parts of the group elsewhere, but even the ubiquitous *Phacops* is not so abundant at other localities as here. Of the other trilobites, several appear to be confined to the paint ore in Pennsylvania, and nowhere else in the State have so many different trilobites come from so small a geologic range of Onondaga strata. The following is the list of the fauna as identified by us from the Lehigh University collection. It is more complete than Willard's preliminary list (5a).

SPECIES IN THE PAINT ORE

Corals
- *Cyathophyllum* cf. *coronatum* Hall
- *Favosites limitaris* Rominger

Crinoids
- Crinoid columnals

Bryozoa
- *Fenestella* sp.
- *Polypora* sp.
- *Cystodictya* sp.

Brachiopods
- *Lingula ligea* Hall
- *Pholidops* sp.
- *Stropheodonta demissa* Conrad
- *Stropheodonta inequistriata* (Conrad)
- *Stropheodonta patersoni* Hall
- *Stropheodonta concava?* Hall
- *Leptostrophia perplana* (Conrad)
- *Leptaena rhomboidalis* (Wilckens)
- *Schuchertella pandora* (Billings)
- *Schuchertella variabilis* Prosser
- *Chonetes mucronatus* Hall
- *Chonetes setiger* (Hall)
- *Chonetes lepidus* Hall
- *Chonetes arcuatus* Hall
- *Dalmanella lenticularis* (Vanuxem)
- *Schizophoria striatula* (Schlotheim)
- *Schizophoria propinqua* (Hall)
- *Atrypa reticularis* (Linné)
- *Spirifer macrothyris?* Hall
- *Spirifer audaculus?* (Conrad)
- *Elytha fimbriata* (Conrad)
- *Anoplotheca acutiplicata* (Conrad)
- *Pentamarella arata* (Conrad)

Gastropod
- *Diaphorostoma lineatum* (Conrad)

Trilobites
- *Cyphaspis minuscula* Hall
- *Phaethanides gemmaeus* Hall and Clarke
- *Conolichas eriopis* (Hall)
- *Acidaspis callicera* Hall and Clarke
- *Phacops cristata* Hall
- *Phacops cristata* var. *pipa* Hall and Clarke
- *Phacops rana* (Green)
- *Phacops* sp.
- *Odontocephalus aegeria* Hall

Ostracods
- *Bolia* sp.
- *Ulrichia* sp.

Ostracoda, undet.

A few remarks on the relative abundance of some of these fossils are significant as showing the abnormal proportioning of the fauna. Corals are scarce, but Bryozoa and crinoid columns are abundant. In this the fauna is not strikingly peculiar. Inarticulate brachiopods are rare here and elsewhere in the Onondaga of Pennsylvania. Of the strophomenoid brachiopods, *Stropheodonta patersoni* and *S. inequistriata* are common, but *S. concava*, rather doubtfully identified from a single example, is unrecorded from elsewhere in the Onondaga group of Pennsylvania. The two species of *Schuchertella* are not common. *Leptaena rhomboidalis* is the commonest brachiopod in the paint ores, and may be collected in large numbers. *Chonetes* occurs as four species. Among these it is noteworthy that *C. lepidus* has not previously been found in the Onondaga of the State. *Schizophoria striatula* was collected and appears to be unique for Pennsylvania and regions south (cf. Maryland). *S. propinqua*, known from the Onondaga of New York is recorded only from the paint ore in Pennsylvania. The two species of *Spirifer*, *S. macrothyris* and *S. audaculus*, are both poorly preserved and their identity open to question. Butts (1) reported *S. macrothyris* doubtfully from the Onondaga of Alabama, but it is otherwise unrecorded from Pennsylvania southward. *S. audaculus* from the paint ore would seem to be unique for the Onondaga of the State. The scarcity of

Anoplotheca acutiplicata is extraordinary. Elsewhere, it is among the commonest of Onondaga fossils, and occurs in all units of the group in Pennsylvania. Only one example was identified from the paint ore at Palmerton. Of the mollusks, as noted, the absence of all but a single snail, *Diaphorostoma lineatum*, is surprising.

The trilobites are interesting both for their abundance and specific diversity. *Cyphaspis minuscula*, *Phaethanides gemmaeus* and *Conolichas eriopis* are here unique from Pennsylvania, and *Acidaspis callicera* is rare. The rest are common. Ostracods are abundant in the paint-ore fauna, but have not been thoroughly studied.

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PALEONTOLOGICAL NOTES

GROWTH LINES IN FOSSIL PECTENS AS INDICATORS OF PAST CLIMATES

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The shell of *Pecten irradians* Lamarck and allied forms shows concentric lamellae about 0.5 mm apart. That one of these is formed each day is proved in three ways: First, young *Pecten irradians* gathered at Cold Spring Harbor, L. I., on September 15 have 56 to 48 lamellae. We know that the shell begins to form on the embryo about August 1 of each year. The interval of 46 days to September 15 agrees approximately with the number of lamellae found. Second, I have broken the edge of the shell of *Pecten* and let it regenerate the edge in a tide box. One lamella was added each 24 hours. Third, I have counted the number of concentric lamellae in some young marked Pectens, returned them to a tide box and counted the number of lamellae after four days. Four lamellae had been added in each case.

All adult *Pecten* shells gathered at Cold Spring Harbor show a sharp concentric line. This is the winter line, caused by a cessation of growth for a period. From a number of counts I find the number of lamellae laid down before the winter line to be about 135 to 145, corresponding to a date of December 16 to 26, which is about the time at which the inner harbor usually begins to freeze over.

Shells of *Pecten gibbus* Conrad (closely allied to *P. irradians*) from Tampa, Florida, show no winter line. Shells of Pectens from Morehead, N. C., which are intermediate between those of Tampa and Cold Spring Harbor, frequently form no distinct winter line, but there is a period when the lamellae are laid down close together and growth is very slow. Assuming that the pectens hatch at Beaufort on the same date as at Cold Spring Harbor, we may infer that the water becomes so cold as to slow up the shell-secreting processes about December 25 to January 22.

Some years ago I visited the Nansemond River near Suffolk, Virginia, and gathered fossil shells of *Pecten eboreus* Conrad from layers 1 foot, 6 feet and 15 feet above tide water, as described by me in 1905 (1). The age at which these shells were deposited is believed to be late Miocene (2). I thought that by looking at these fossils I might determine the date of coming on of winter—always assuming development of the egg to begin August 1.[1]

Shells from the upper layers of the river bank, indeed, show a winter line which is very distinct, more so than in recent shells from Beaufort, N. C., indicating harder winters than now occur at Beaufort. Also, the number of lamellae to this winter line is smaller than at Beaufort or at Cold Spring Harbor. On two shells I counted approximately 100. If development of the shell began August 1, freezing weather set in about November 1.

The assumption that reproduction took place August 1 is probably not justified. If winter came on earlier than it does now at Cold Spring Harbor, the onset of summer was probably correspondingly retarded. It takes a fairly uniform time for the ovaries of the mother *Pecten* to reach their full size after the

[1] Gregorian calendar dates are used for convenience. Properly, we should say "40 days after the summer solstice."

plankton has begun to show the spring increase. If reproduction was retarded 3 weeks, or until August 21, then winter set in about 100 days later, or approximately December 1.

The conclusion seems to follow, then, both on account of the marked winter line in the shell of *Pecten eboreus* and the small number of daily lamellae formed up to the winter line, that winter set in much earlier in southern Virginia during the late Miocene than at present and that the late Miocene was relatively colder than today.

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A PTEROPOD RECORD OF CURRENT DIRECTION

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In sandy sediments current ripple mark when present supplies infallible evidence concerning the direction of the current responsible for it. The steep short slopes of assymmetrical ripple mark facing away from the current and the long gentle slopes rising with it are however absent or rare in many sandstones. In some sandstones such records of current direction abound. In others where ripple mark is rare fossils sometimes give this kind of information. Fossils with streamlined symmetry of the elongate conical type

FIG. 1.—Sandstone slab containing pteropods (*Tentaculites carteri* Clarke) oriented in conformity with two currents trending in the directions indicated by the arrows. ×½.

are the kinds most likely to record such evidence. Those which may yield information concerning current direction are largely limited to the Pteropoda, the straight shelled nautiloid cephalopods, and a few gastropods with long tapering spires like the Turritellas and the Terebras of the Tertiary.

Current ripple mark appears to be rare in the Gaspé sandstone, but reliable information regarding current direction is sometimes recorded by the orientation of some of the larger Pteropods when they occur in great abundance. Under optimum conditions, the elongate conical shape of these shells causes currents of the proper strength to orient them with the apex pointed toward the current and the long axis parallel to it. This is the position of maximum stability in a current, but it would not be maintained in the presence of wave action. When this parallel orientation of Pteropod shells is met with in a sandstone, it signifies prompt burial of shells by current-transported sand laid down by currents before wave action had an opportunity to disturb the orientation left by the currents.

The sandstone slab here figured (fig. 1.) shows on one side many shells of *Tentaculites carteri* Clarke lying at two levels about one quarter of an inch apart in the block. In one of these, six of the eight shells lie approximately parallel and show the apex of each pointing in the same direction. The other level contains 28 shells, of which 24 lie within a few degrees of parallel to one another; the remaining four have divergent directions. The reverse side of the slab shows a large number of pteropods, the majority being oriented in the direction of the first group, but without uniformity as to the direction in which the apex points. An overabundant supply of these slender cones or a weak current probably impedes upstream orientation of the apical ends. The specimen figured was collected by Dr. I. W. Jones near the mouth of Fourth Lake Brook, Gaspé County, Quebec.

One may readily demonstrate the strong tendency of gently tapering conical objects to assume a position in accord with current flow by using long slender wood screws that have been modeled into elongated cones with plasticene or putty. When dropped haphazard into a water current a large proportion will speedily take up positions with the large end down stream and the apex upstream.

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AGRAULOS GIBBUS, NEW NAME FOR AGRAULOS CONVEXUS HOWELL, PREOCCUPIED

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One of the new trilobites of the Cambrian *Centropleura vermontensis* fauna of Vermont described by the writer in 1937[1] was named *Agraulos convexus*. Dr. C. E. Resser has kindly called the writer's attention to the fact that this name was applied to another Cambrian trilobite by R. P. Whitfield in 1878.[2] Therefore, although Whitfield's species has since been made the genotype of another genus, *Camaraspis* Ulrich and Resser, the name *Agraulos convexus* is not available for the Vermont form, and it becomes necessary to propose a new name.

The writer would therefore substitute for the preoccupied name the new one, *Agraulos gibbus*.

[1] *Geol. Soc. Am., Bull.*, vol. 48, p. 1188, pl. 5, fig. 15, 1937.

[2] *Wisconsin Geol. Survey, Ann. Rept. for 1877*, p. 57, 1878.

GEOLOGIC AGE OF TEREBRATULA UTA MARCOU

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In their discussion following the description of *Wellerella osagensis*, Dunbar and Condra remarked (1) "In 1928 Mathews showed that the types of *Pugnax uta* Marcou came from the Triassic beds in the Wasatch Range above Salt Lake City, and are quite distinct from our Pennsylvanian shells." It is true that Mathews seems to have been under the impression that he "showed" *Terebratula uta* to be a Triassic species, but a little examination of the facts should make it clear that Mathews did not show anything of the sort.

Dunbar and Condra give as reference to Mathews' paper an abstract (2), which I quote.

"The first paper gave a short review and new description with lantern slide illustrations of the supposed Coal Measures brachiopod *Terebratula uta* Marçou and showed that it is of Triassic age. The discussion indicated that other species described from this region would be found to be of Mesozoic age instead of Paleozoic."

This is followed by what appears to have been the title of the paper, "*Terebratula uta* Marcou—a Triassic species." As to the other species that would be found to be of Mesozoic age instead of Paleozoic, the only ones of which this is true have long been known to be so. I refer especially to the species described as from the foothills near Salt Lake City. As regards the subject in hand, I have known for many years that the Lower Triassic faunas of the Great Basin region contain a rhynchonellid very similar to the common Pennsylvanian species which has of late generally been cited as *Pugnax uta*. In fact, a year before the abstract of Mathews' paper was published, I described (3) a species of this character (there are probably several others) as *Pugnoides triassicus*. My specimens of this Triassic species were collected in 1910 in the Montpelier quadrangle, Idaho, and it is not surprising that Mathews found a similar form at the same horizon near Salt Lake City.

I have said that Mathews did not show that *Terebratula uta* is a Triassic species for the reason that the evidence (and we are compelled to accept it until it is shaken) demonstrates conclusively that *Terebratula uta* is a Carboniferous species. The most that Mathews could show is that the same species occurs in beds of Triassic age, and I doubt if he did or could show even that, inasmuch as Marcou's description and figures are not of the best. In fact, as the internal structure of authentic *P. uta* is unknown, no species can be definitely grouped with it even generically. My statement that *Terebratula uta* is a Carboniferous species rests on the fact that Marcou says that *Terebratula uta* was found associated with *Terebratula* (*Hustedia*) *mormoni*, *Terebratula* (*Composita*) *roissyi*, *Terebratula* (*Composita*) *subtilita* and *Productus semireticulatus*. My faith in the accuracy of Marcou's statements is no more implicit than anyone's else, but beyond the statement just cited it is not at this time permitted to go. Insofar as anything can be deduced from the abstract, Mathews had no evidence for saying that *Terebratula uta* was a Triassic species other than the two facts that it was described as having come from the vicinity of Salt Lake City and that some Triassic rocks near Salt Lake City contain a species similar to it. To me this would be very insecure evidence for the conclusion reached by Mathews, even if there was nothing to contradict it, and it cannot stand at all against Marcou's statement that *T. uta* was found in association with

a fauna manifestly of Carboniferous age. Of course it might be claimed that the faunal association ascribed to *Terebratula uta* by Marcou is untrustworthy, so that Mathews' conclusion would be at least somewhat credible, but, on the other hand, it might be claimed that the locality of occurrence ascribed to *Terebratula uta* and the associated fauna is untrustworthy, which would destroy what little substance can be found in Mathews' evidence. One claim is as good as the other, and so far as I am aware neither of them is supported by a scrap of evidence.

I may here make note regarding another of Marcou's species, that described as *Terebratula rockymontana*, though it may seem ungracious to do so, and it certainly is not germane to the subject of this article. Under the heading of *Leiorhynchus rockymontanum* Marcou, Dunbar and Condra profess to give the "original description" which runs to nearly half a page; the quoted matter is not the original description but is taken from my Wewoka report (4). It is, of course, gratifying that my description of the species proved to be acceptable to these authors.

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KINDERHOOK CONODONTS FROM LITTLE ROCKY MOUNTAINS, NORTHERN MONTANA

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Stratigraphic studies made recently in the Little Rocky Mountains, Phillips and Blaine Counties, Montana, have revealed the presence there of a thin fossiliferous shale unit overlying limestone of Devonian age and forming the base of the Lodgepole limestone, the lower of the two formations of the Madison group (Mississippian) that were recognized by Collier and Cathcart (1). Though the shale is so thin and exposures of it are so rare that no attempt is made to map the unit as a formation, it has been observed at several scattered localities in the Little Rockies, including three small tributaries of Peoples Creek in the northwestern part of the area. It is possibly the correlative of certain occurrences of shale in other parts of Montana and in Alberta that are referred to elsewhere in this note. The following beds are exposed in sec. 5, T. 25 N., R. 24 E., in the Little Rockies:

SECTION ON TRIBUTARY OF PEOPLES CREEK

	Ft.	*In.*
Mississippian, Madison group, Lodgepole limestone:		
Upper member: Thick sequence of very fossiliferous thin-bedded limestones, occasional very thin layers and lenses of shale and local lenses of chert.		
Basal shale member:		
Black sandy shale containing conodonts		4–10
Sandy light-brown and gray mudstone		2–8
Dark sandy shale containing conodonts		2–4
Light-gray clay	4+	
Covered zone of undetermined age	10	(or less)
Devonian: Sequence of limestone beds.		

A preliminary examination of the conodont fauna represented in random samples of several layers of the shale (USGS collection

8432) has been made by the junior author. Mr. C. L. Cooper, of the Illinois State Geological Survey, very kindly checked a number of the identifications and offered helpful suggestions. The genera and species that have been noted are as follows:

CONODONTS IN THE BASAL SHALE MEMBER OF THE LODGEPOLE LIMESTONE

Bryantodus 3 n. sp.
Hindeodella 4 n. sp.
Ligonodina 2 n. sp.
Ozarkodina n. sp.
Palmatodella fragosa E. R. Branson
Palmatolepis aff. *P. rugosa* Branson and Mehl
Palmatolepis, fragments of several species
Polygnathus aff. *P. communis* Branson and Mehl
Polygnathus inornata E. R. Branson
Polygnathus 7 n. sp.
Prioniodus 7 n. sp.
Pseudopolygnathus cf. *P. asymmetrica* E. R. Branson
Pseudopolygnathus 13 n. sp.
Siphonognathus duplicata Branson and Mehl
Siphonognathus quadruplicata Branson and Mehl
Siphonognathus n. sp.
Solenognathus 2 n. sp.
Spathodus 5 n. sp.
Synprioniodina n. sp.
Trichognathus, fragments of several species

Most of the species appear to be new, and, while this perhaps would be expected since few conodont faunas have been described from the northwestern part of the United States, no doubt a larger collection would show that some of the specimens now considered as new species fall within the limits of variation of other species listed above or previously described. However, on the whole the fauna of collection 8432, when compared with described faunas, is found to be most like the Kinderhook assemblages from the Bushberg sandstone member of the Sulphur Springs formation and from the Hannibal shale of northeastern Missouri.

Though stratigraphic ranges of conodont genera and species are not well known, Branson and Mehl (2) have indicated certain genera that seem to be sufficiently limited in their ranges to have stratigraphic value. Three of these genera are represented in this collection. Two, *Pseudopolygnathus* and *Siphonognathus*, have not been noted by Branson and Mehl in strata older or younger than the beds that they consider to be of Kinderhook age (2*c*). However, the range of *Siphonognathus*, may be greater than that stated above, for, as indicated later, it is probable that a Devonian species now referred to *Polygnathus* is a *Siphonognathus*. The third genus, *Palmatolepis*, is believed by Branson and Mehl to be "diagnostic of middle and upper Devonian, and of basal Mississippian if the Grassy Creek, Huron, Chattanooga Hardin, and Woodford are Mississippian" (2*a*), but this restriction of range to rocks which they consider to be of pre-Kinderhook age is qualified by them in a later statement to the effect that *Palmatolepis* does occur in Bushberg faunas but only as re-worked material (2*b*). In the present collection, though specimens of *Pseudopolygnathus* and *Siphonognathus* are very abundant, yet whole and fragmentary specimens of *Palmatolepis* are rather common.

Palmatodella fragosa, *Pseudopolygnathus asymmetrica*, *Polygnathus communis*, *Polygnathus inornata*, *Siphonognathus duplicata*, and *Siphonognathus quadruplicata*, six of the seven species with which forms in collection 8432 are identified or compared, have been reported only from formations of Kinderhook age. All six are present in the Hannibal shale and the four last named also occur in the Bushberg sandstone member of the Sulphur Springs formation. It is probable, however, that *Polygnathus newalbanyensis* Huddle, from the upper part of the New Albany shale in southern Indiana, is generically, if not specifically, the same as *Siphonognathus quadruplicata*, one of the species listed above. But, even if these two species are congeneric, and the range of *Siphonognathus* were extended to include strata of Devonian age, not only would collection 8432 still contain one genus and five species characteristic of formations of undoubted Kinderhook age, but also it would lack the generic assemblage said by Branson and Mehl (2*a*) to be characteristic of horizons ranging from the Middle Devonian through basal Mississippian (?).

The seventh species is represented by specimens that are almost identical with *Palmatolepis rugosa*, a species in the Grassy

Creek shale. According to Branson and Mehl (2*b*) the presence of *Palmatolepis* in the Bushberg fauna of northeastern Missouri, which is undoubtedly of Kinderhook age, is due to stratigraphic admixture, but it would be a curious coincidence if a similar admixture also occurred in a collection from Montana. It seems more probable that the stratigraphic range of *Palmatolepis* is greater than has been supposed and that its presence in beds of Kinderhook age is in no way anomalous.

It may be suggested, for later possible confirmation, that the basal shale of the Lodgepole is the stratigraphic equivalent in the Little Rockies of the "black fissile shale" described by Moore (3) and Perry (4) as occurring above Devonian beds in southern Alberta and in the Sweetgrass Arch of northwestern Montana, and by Deiss (5) at the base of the Mississippian Madison limestone at Half Moon Pass in the Big Snowy Mountains of central Montana. Perry described the dark shale of the Sweetgrass Arch as "oil shale" and included it as the "upper limit" in his Potlatch anhydrite, which he tentatively regarded as Devonian. The basal shale member of the Lodgepole limestone in the Little Rockies yields little or no petroliferous matter when heated and is not underlain by anhydrite at any of the localities at which its base has been found exposed is this area. Deiss mentions the presence of conodonts in the shales at Half Moon Pass, but Moore's and Perry's descriptions contain no reference to conodonts at their localities in Alberta and northwestern Montana. The species collected by Deiss have not been described or listed in any publication seen by the writers.

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